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A Psychoeducational Evaluation of Precursors to Learning Disabilities in the Very Low Birthweight Population at 5 1/2 Years

BY

© Marliss E. Meyer

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DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

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M. Meyer

15708 - 73 A Avenue
Edmonton Alberta
T5R 2Y1

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled A PSYCHOEDUCATIONAL EVALUATION OF PRECURSORS TO LEARNING DISABILITIES IN THE VERY LOW BIRTHWEIGHT POPULATION AT 5 1/2 YEARS submitted by MARLISS E. MEYER in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY.

Richd Sobsey
(Supervisor)

James Blakey

L. Wilgosh

Charlene Robertson

R.H. Short

Carol Crealock

Date: September 28, 1988

DEDICATION

This thesis is dedicated

to my mother

and to Jessica and Hilary.

ABSTRACT

Past research has implicated very low birthweight (VLBW) as a causal factor in the development of learning disabilities. Perceptual motor deficits, language difficulties and attention deficit behavior have been isolated as problem areas contributing to the school difficulties of the VLBW group. The interaction of low birthweight, inherent potential, and effects of subsequent life experiences associated with socio-economic status has been demonstrated as well. Long-term prognosis is also associated with the gender of the child, with male sex conferring a definite disadvantage. The present study has focussed upon precursors to learning disabilities in the VLBW population and the effects of various factors. Data were collected from 110 nondisabled VLBW subjects, who were appropriate weight for gestational age at birth, and 197 full birthweight (FBW) subjects. A test battery was individually administered to all subjects at 5 1/2 years of age. When the test performance of the VLBW group was compared with the norms of the tests, significant differences occurred on several variables, however, when compared with the test performance of the FBW group, differences were non-significant. Comparing the VLBW and FBW groups did produce a significant overall difference, which was, most likely, due to the general trend towards weaker scores among the VLBW sample. No significant differences were found in comparisons of the test results of male and female subjects. Effects of gestational age and birthweight were also non-significant. The overall effect of mother's age upon test performance was non-significant, however, the scores of children born to the youngest mothers were significantly lower than the performance of other subjects grouped together. There was a definite trend toward decreased scores with decreased socio-economic status or with decreased IQ. Behavior was the most efficient variable in differentiating the VLBW from the FBW subjects and was found to produce significant impact upon test performance. Stronger performance was seen in the normal behavior category when compared with the suspicious and 'hyperactive' groups. It was concluded that cognitive skills and preschool readiness skills were very similar for the VLBW and FBW samples, however, the possibility of generalization regarding the extent of learning disabilities in either group was limited.

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CHAPTER I

Introduction

Overview of the Problem

Improvements in obstetric care, advanced technology in the mechanics of life support, and increased knowledge of the physiology of the neonate have influenced the survival rate of sick or premature infants, in addition to decreasing chances for postnatal morbidity (Robertson & Etches, 1988). Prior to the advent of the neonatal intensive care nursery in the 1960's the risk of neonatal death was 17.9 per 1000 live births in the U.S.A. compared with 12.1 per 1000 live births in the 1970's, with newborn infants of birthweight under 2501 grams accounting for 67% to 75% of neonatal deaths (Thompson & Reynolds, 1977). Survivors of small, premature birth were at risk for developmental handicaps (Dann, Levine, & New, 1964; Drillien, 1961; Lubchenco, Norner, Reed, Hix, Metcalf, Cohig, Elliott, & Bourg, 1963; McDonald, 1962, 1964). Predictions were made that intensive care management of low birthweight infants would increase the number of survivors with a concomitant increase in the number of handicapped individuals entering society (Drillien, 1967; Holt, 1972).

The history of neonatal care has seen swings in mortality and morbidity statistics with changes in the regime of treatment. Kitchen (1978) and Hack, Fanaroff, and Merkatz (1979) summarized the history of neonatal treatment into four phases. Phase one, typifying care early in this century and involving simple measures of nursing care, tube feeding, and extra warmth, enabled a few vigorous infants to survive initially, but with an exceedingly high post-neonatal death rate. The long term survivors were relatively free of serious handicaps, but they were a small, highly select population, presumably contending with the fewest hazards at the time of birth. The 1946 Maternity Survey (Douglas & Gear, 1977) reported that no baby under 1000 grams survived, but that of fourteen survivors of birthweight under 1501 grams, none had major handicaps when examined at follow-up at age fifteen years.

In Phase two, lasting from the late 1940's to the early 1960's, active medical treatment for low birthweight infants began. During that time mortality declined, but handicap among survivors was high. Treatment was punctuated by many setbacks. Retrolental fibroplasia was produced by overuse of oxygen, but restriction of oxygen usage lead to increased neurological damage or neonatal deaths. Delays in initial feeding, thought to be sound practice, resulted in dehydration, starvation, and jaundice. Drugs used experimentally produced unexpected results. Infants were isolated from mothers and families affecting the mother-child bonding and also the stimulation of the infant. In Scotland, Drillien (1961) followed fifty children less than 1360 grams at birth. At five years of age 58% had either physical defects or obvious mental handicaps. Out of 94 survivors born in Denver, Colorado, weighing less than 1501 grams at birth, 63% had visual handicaps, cerebral palsy, or mental retardation (Lubchenco, Horner, Reed, Hix, Metcalf, Cohig, Elliot, & Bourg, 1963).

Phase three, from the late 1960's to the early 1970's, brought improved prenatal care and advice for parents, improved infant care, greater understanding of the physiology of the newborn, better technical skills, and some understanding of the complicating effects of social conditions. Facilities for prompt resuscitation and ventilation of distressed infants, use of monitoring devices and bio-chemical analyses, and greater availability of intensive care meant improved prognoses for the low birth weight group (Stewart, Reynolds, & Lipscomb, 1981). Incidence of spastic diplegia declined from a range of 7 - 12% to 4% (Davies & Tizard, 1975; Hack, Fanaroff, & Merkatz, 1979). Comparable reductions in blindness and hearing loss were reported (Francis-Williams & Davies, 1974). However, school performance tests suggested an increased incidence of learning, reading, and behavior disorders despite presumably normal intellectual development (Drillien, Thomson, & Burgoyne, 1980; Hunt, 1981; Kitchen, Rickards, Gaudry, Brenton, Billson, Fortune, Keir, Lundahl, & Hegedus, 1978; Wright, 1972).

Care of the very low birthweight infant is now in phase four. Characteristic of this phase is the expansion of services in the community. An emphasis on public and professional education, better service for mother and newborn, comprehensive follow-up of high risk survivors, more uniform data collection and record keeping, and increasing clinical teams of specialists to apply skills and knowledge in areas of psychology, social service, occupational therapy, and education may result in much improved long-term outcome statistics for the low birthweight infant.

This implies continued surveillance, intervention, and treatment of specific handicapping conditions when the risk is identified. The major handicaps, definite cerebral palsy, convulsive disorders, an intelligence quotient below 75, severe deafness or visual loss, are usually diagnosed and dealt with before a child reaches school age. Minor handicaps, on the other hand, are more difficult to diagnose as many border on normality.

In-depth screening for minor handicaps in the low birthweight group may be warranted if such handicaps are found to be present in sufficient numbers, particularly in cases where early identification and treatment would lead to resolution of the problem, the instigation of compensatory measures that would ease the burden of the handicap, or the early introduction of special services that may be more effective if established before the complications of operating with an unidentified disability arise.

The purpose of this study is to investigate the possibility of decreased functioning on a variety of subtests designed to measure learning processes related to learning disabilities (a condition of minor handicap) in a population of very low birthweight children described as free from major handicaps at age 5 1/2 years. Of interest is a description of the extent and types of learning problems that may be present as well as a determination of the influence of socio-economic status, gender, gestational age and mother's age upon the learning patterns exhibited by this group of children.

Rationale for the Study

Newborn infants of birthweight less than 1500 grams numbered 335 in Alberta in 1979, which was the final birth year of children in this study. Although this represents less than one percent of the 37,524 live births in the province that year, the group constituted greater than ten percent of the neonatal intensive care admissions (Robertson, 1980).

Investigations into the ramifications of very low birthweight upon the future learning patterns of this group are of importance not only to the child, but also to the child's parents, to community service agencies, and to the neonatal intensive care unit where the child was originally treated.

If, indeed, an increased possibility of developing learning disabilities exists among the very low birthweight population, awareness of this may lead to closer follow-up of the group and subsequent early identification of the children most at risk. Satz and Friel (1974) have suggested that remediation should occur in the preschool period, at a time when the central nervous system may be more plastic and responsive to change. Effectiveness of intervention efforts is, therefore, greater (Mercer, Algozzine, & Trifiletti, 1979). More importantly, it is only by identifying specific learning disabilities in the preschool years, and by providing remedial techniques or recognizing the need for alternative teaching strategies, that it is possible to avoid the problem of treating conditions worsened by the emotional overlay of repeated failure (Buktenica, 1971; Fox, 1979; Meier, 1976; Satz & Freil, 1974; Trehub, 1977).

More specifically, preschool intervention programs for early remediation of pre-academic processing difficulties must be based upon sound knowledge of the learning profiles of the children to be treated.

A clearer picture of the types of learning problems most common among very low birthweight children should lead to more effective programming.

From the point of view of parents, the proportion of survivors of very low birthweight who will experience difficulties in school is very important. General family management practices, both in the home and in seeking outside assistance from service agencies, are guided by an understanding of the child's needs and capabilities. Difficulties arise if false expectations for either achievement or failure are set.

For planning services in the community it is essential to know the numbers of disabled children that might be expected from a certain population and at what ages the services may be required. The types of services required will also be dictated by the specific forms of disabilities exhibited.

Since it is possible that the defects of very low birthweight children are due not only to the intra-uterine factors causing the premature birth or to the immaturity of the infant, but also to the infant's management in the neonatal period (Drillien, 1972; Fitzhardinge & Ramsay, 1973) a determination of long term effects of changes in treatment are essential for judging the effectiveness of treatment. Regional neonatal follow-up studies provide local outcome statistics which can provide a basis for changes in obstetrical and neonatal care resulting in fewer handicaps along the continuum from severe to mild handicapping conditions including learning disabilities.

CHAPTER II

Literature Review

Birthweight Categories

In 1948, the World Health Assembly noted low birthweight as a world wide problem and defined infants as premature if they were born weighing less than 2500 grams (Petros-Baravazian & Behar, 1978). In developed countries, 4% to 8% of all children have such a low birthweight (LBW) and the incidence is higher in lower social classes and in developing countries. In fact, it has been estimated that there are about 22 million live born LBW babies in the world each year, representing about one-sixth of the total number of global live births (Dunn, 1981).

In Alberta, in 1979, of 37,524 live born infants, 2,514 (6.7%) were less than 2500 grams at birth. This group was composed of 2,179 (5.8%) infants of birthweight 1501 to 2500 grams and 335 (.9%) infants of 500 to 1500 grams (Robertson, 1980).

About 30% to 40% of infants with a birthweight of 2500 grams or less in the developed countries are actually born at term (at or after 37 completed weeks of gestation). The proportion is higher in an unfavorable socio-economic environment, and in the developing areas approximately 16 out of 21 million LBW infants each year are full term infants. Accordingly, in 1961, the Expert Committee on Maternal and Child Health established by the World Health Organization recommended that babies weighing 2500 grams or less should no longer all be referred to as being 'premature' and that the concept of 'prematurity' as previously defined should give way to that of low birthweight. As the group of babies 1500 grams or less at birth contained a disturbingly high proportion of children with a variety of mental and physical handicaps compared with those babies of 1500 to 2500 grams, children of birthweight less than 1500 grams are termed very low birthweight (VLBW) infants.

Infants with birthweights of 1500 grams are on average born nine weeks before term, with a gestational age of 31 weeks as compared with 40 weeks for the full term infant, while gestational age for those weighing 1000 grams is likely to be approximately 27 weeks or three months premature (Hunt, 1981). Survivors have been reported as young as 24 weeks gestational age or with birthweights below 500 grams (Robertson & Etches, 1988).

Lubchenco and her colleagues (Babson, Behrman, & Lessel, 1970; Lubchenco, Hansman, Dressler, & Boyd, 1963) devised intrauterine growth curves from live born birthweight data in relation to gestational age. Infants born prior to 37 weeks of gestation, whose weight lies between the 10th and 90th percentiles on such curves may be termed premature, but appropriate for gestational age (AGA), whereas babies whose birthweight is below the 10th percentile may be called dysmature or small for gestational age (SGA).

Thereby, children of low birthweight may be subdivided into two major categories, namely those who are born pre-term, but have grown appropriately for their gestational age and those who are born at the expected time, but from their weight are assumed to be undergrown. The risks faced by these two groups of low birthweight infants are somewhat different.

Michaelis, Shelte, and Note (1970) compared 22 SGA babies, born between 38 and 42 weeks gestation and below the 5th percentile in birthweight, with 25 normal weight newborns, born between 39 and 41 weeks gestation and with birthweights between the 10th and 90th percentiles. It is assumed that some adverse condition during pregnancy was responsible for the decreased birthweight, since gestation period was normal. Reflexes and complex motor phenomena were studied to test the hypothesis that maturation of the central nervous system and the motor development of the newborn infant would be more closely related to conceptual age than to birthweight. It was expected that motor behavior of full term, SGA infants would be similar to that of newborn infants of normal weight at term, however, there were significant differences between the groups, suggesting that development of motor and complex reflex behavior is dependent not only upon gestational age. Factors influencing the intrauterine growth retardation also influenced, to varying degrees, the later functioning of the child.

To clarify this point, Drillien (1972) reclassified the SGA and AGA groups, concluding from her studies that most low birthweight infants fall into one of three aetiological categories with different prognoses for outcome. The babies affected by adverse factors in early gestation make up the first group. These babies may be born full term, but still have the highest risk of moderate or severe handicap. There are more congenital and intrauterine infections in this group. The majority of these children are small for gestational age. In Drillien's 1980 study, this group comprised only 16% of the total VLBW sample, but 44% of the severe handicapping conditions originated with them. School difficulties were experienced by 41% of the group.

The babies subject to adverse conditions in late pregnancy comprise the second group. They are less likely to have major handicaps, but may show increase in mild degrees of mental retardation and minor neurological abnormalities. Again, most of these infants are SGA.

The third group includes the babies who are prematurely delivered 'by accident' with no prior adverse conditions. These babies are potentially normal at birth. Their later status depends largely upon the extent of complications at delivery and the quality of postnatal care. Most of the infants of birthweight appropriate for gestational age are from this group.

These differences in aetiology are recognized by researchers, but most continue to categorize infants as either AGA or SGA as, in many cases, it is difficult to determine the nature of the intrauterine difficulty producing the retardation in growth of the fetus. The AGA and SGA categories are more definitive.

Much research since the 1970's has focused on infants who are SGA as a particularly high risk group. In a follow-up study from Toronto, of infants with birthweights less than 1500 grams, born in 1974, among those at highest risk of later handicap were the infants who were SGA, 53% of whom were significantly handicapped at two years (Fitzhardinge, Kalman, Ashby, & Paper, 1978). Sabel, Loegard, & Victoria (1976) found that the neo-nates, born in Sweden during 1969 to 1970, at highest risk for demonstrating cerebral palsy and/or psycho-motor retardation on follow-up examination at three years were those who had evidence of intrauterine insult or malnutrition, not the AGA low birthweight infants. Davies (1975) reported that visual and auditory defects as well as low I.Q.'s were significantly more common in the SGA group. Eaves, Nuttal, Klonoff, and Dunn (1970) and Francis-Williams and Davies (1974) also found that SGA infants score significantly lower on measures of intelligence than those who were AGA. Other authors have described the high incidence of neurological or developmental handicaps among the SGA infants (Babson & Philips, 1974; Fitzhardinge & Ramsay, 1973; Fitzhardinge & Stevens, 1972; Lubchenco, Bard, Goldman, Coyer, McIntyre, & Smith, 1974; Parmelee, Minkowski, Dargassies, Dreyfus-Brisac, Levine, Berges, Chervin, & Stern, 1970).

Lubchenco (1976) summarized the complex effects of both birthweight and gestational age in determining outcome, with the lowest birthweight and least gestational age producing the greatest problems. Figure 1 presents her conclusions regarding I.Q., birthweight, and gestational age. The mean intelligence quotient is given for each block described by birthweight and gestational age. Mean I.Q. increased with increasing birthweight, but weight appropriate for gestational age definitely placed the child at an advantage for more positive outcome. Figure 2 plots the estimated percent risk of moderate to severe handicap by birthweight and gestational age for the group born at less than 1500 grams (Lubchenco, Delivoria-Papadopoulos, & Searls, 1972), the highest incidence of handicaps occurring in infants who had short gestations.

Figure 1

from Lubchenco 1976 p. 245

Figure 2

from Lubchenco, Delivoria-Papadopoulos & Searls 1972 p. 509

Improvement is noted in later outcome with advancing gestational age even in the 1000 to 1200 gram group, the best prognosis occurring in infants over 1350 grams with a gestation age of more than 31 weeks, which includes some infants with intrauterine growth retardation.

The abbreviations to be employed, throughout this paper, for the various birthweight categories have been summarized in Table 1. Terminology referring to different degrees of morbidity is also defined in Table 1. Attempts have been made to apply the terminology according to these definitions however, where this differed from an author's use of terms the word employed in the original article has been retained.

Table 1

Birthweight Categories

Abbreviation or Term	Definition
LBW	- low birthweight, less than 2500 grams, or approximately 5 1/2 pounds at birth
VLBW	- very low birthweight, less than 1500 grams, or approximately 3 1/2 pounds, at birth
FBW	- full birthweight, approximately 3000 to 3500 grams, or 7 to 7 1/2 pounds, at birth
SGA	- small for gestational age, below the 10th percentile on the growth curve for gestational age
AGA	- appropriate for gestational age, between the 10th and 90th percentile on the growth curve for gestational age
Impairment	- actual physical or structural deviation from the normal. It may have little or no practical consequence.
Disability	- restriction or lack of ability resulting from an impairment
Handicap	- disadvantage accruing to the individual by virtue of the impairment or disability

Outcome Statistics from Follow-up Studies

Survival Rates.

The research literature on outcome statistics for the LBW infant provides evidence of an encouraging trend in survival rates, the most readily available and easily verified data. Thompson and Reynolds (1977) summarized international mortality rates from developed countries and tabulated the information as percent change before and after the introduction of neo-natal intensive care units in various treatment localities. Their figures show an improvement of approximately 40% in the under 2000 gram and under 1500 gram groups, and an improvement of approximately 25% for the group less than 1000 grams at birth. Survival rates from various other studies have been summarized by the author in Table 2. Where possible, rates were reported for exclusive groupings, i.e. less than 750 grams, 750 to 1000 grams, 1001 to 1250 grams, 1251 to 1500 grams. Although inconsistent, the statistics indicate that chances for survival improve with an increase in birthweight. Range of survival rates for the less than 750 gram group is 3% to 44%, less than 1000 grams - 13% to 60%, less than 1250 grams - 30% to 93%. Irregular improvements can also be seen from the 1960's to the 1970's. Since perinatal mortality figures are considered to be a good indicator of perinatal care, these changes are most likely due to widespread availability of intensive care units for neo-natal infants in major hospitals.

Table 2

Summary of Neonatal Survival Rates by Birthweight Groups

Author	Year of Birth	Survival Rate	N
< 750 grams			
Stewart & Reynolds 1974	1966-70	5%	1/19
Stewart et al. 1977	1966-75	8%	3/37
Jones et al. 1979	1961-75	0%	0/35
Yu & Hollingsworth 1979	1977-78	44%	7/16
Kumar et al. 1980	1974-77	3%	1/31
Hunt, Tooley & Harvin 1982	1965-69	9%	0/8
	1970-75	8%	1/12
	1976-81	22%	6/27
< 1000 grams			
Alden et al. 1972	1965-70	13%	20/154
*Stewart & Reynolds 1974	1966-70	32%	13/41
Grassy et al. 1976	1968-72	29%	28/98
*Stewart et al. 1977	1966-75	41%	45/111
*Black et al. 1977	1971-73	22%	NR
Pape et al. 1978	1974	47%	20/43
Bhat et al. 1978	1974-76	31%	16/52
*Jones et al. 1979	1961-75	17%	13/75
*Yu & Hollinsworth 1979	1977-78	67%	26/39
*Kumar et al. 1980	1974-77	41%	19/46>
*Peacock & Hirata 1981	1972-75	14%	3/21
*Hunt, Tooley & Harvin 1982	1965-69	27%	7/26
	1970-75	25%	6/24
	1976-81	60%	46/77

* indicates 750-1000 grams

continued

Table 2. continued

< 1250 grams			
Fitzhardinge & Ramsay 1973	1960-66	33%	39/118
*Stewart & Reynolds 1974	1966-70	62%	38/61
Fitzhardinge et al. 1975	1970-72	30%	19/63
*Jones et al. 1979	1961-75	32%	36/112
*Kumar et al. 1980	1974-77	73%	40/55
*Hunt, Tooley & Harvin 1982	1965-69	55%	17/31
	1970-75	71%	29/41
	1976-81	86%	70/81
* indicates 1000-1250 grams			
< 1500 grams			
Wright et al. 1972	1952-56	44%	70/159
*Stewart & Reynolds 1974	1966-70	75%	57/76
Douglas & Gear 1976	1946	32%	14/44
Molteno et al. 1976	1972-73	69%	59/86
Black et al. 1977	1971-73	66%	NR
*Jones et al. 1979	1961-75	73%	99/135
Peacock & Hirata 1981	1972-75	62%	102/164
*Hunt, Tooley & Harvin 1982	1965-69	60%	21/35
	1970-75	80%	41/51
	1976-81	93%	97/104
* indicates 1250-1500 grams			

Rates of Disability.

It is more difficult to generalize about morbidity rates as long term outcome for very small pre-term infants is less easily determined. Table 3 presents a summary of follow-up studies of babies born from 1940 to 1977. The studies are grouped according to birthweights of less than 1000 grams, 1250 grams, 1500 grams, and 2000 grams. Outcome variables in the table include I.Q. defect, major central nervous system defect, and total defects. Table 4 presents a summary of similar data for infants of decreased gestational age born between 1949 and 1972. As can be seen from the tables, results of follow-up studies vary. All seem to indicate an increased index of intellectual deficit and central nervous system defect, but examination of the studies reveals that the actual percent of handicap is not obtained in a standard way. From study to study, length of follow-up ranges considerably, measurement tools and techniques differ, definitions of handicap and areas of disability vary, and the populations of infants are subject to changing classifications. Some studies employed complex psychological, neurological, and medical test batteries, while others have based their findings on the results of group intelligence tests. Some classify birthweights into 250 gram categories, while others group all infants together. There are also differences in the selection of patients, the social class structure of the populations served, and the standard of antenatal and obstetric care.

Table 3

Summary of Low Birthweight Follow-up Research

Author	Birth Date	N	I.Q. Defect	% CNS Defect	% Total Defect
< 1000 grams					
Dann et al. 1964	1940-57	100	41%<90	3	15
Alden et al. 1972	1965-70	20	40%<90		50
Lubchenco 1972	1949-53	13			85
Fitzhardinge et al. 1976	1970-73	18			44
Grassy et al. 1976	1968-72	27		15	30
Stewart et al. 1977	1966-74	27		7	
Teberg et al. 1977	1964-70	40	28%<90 DQ	25	33
Pape et al. 1978	1974	43	21%<80	9	30
Yu & Hollinsworth 1979	1977-78	32		3	3
Bhat 1978	1974-76	16			25
Kumar et al. 1980	1974-77	15			13
Saigel S et al. 1988	1977-80	110			24
	1981-84	122			17
< 1250 grams					
Lubchenco 1972	1949-53	20			70
Fitzhardinge & Ramsay 1973	1960-66	32	43%<90	3	41
Dweck et al. 1973	1968-70	14	14%<90	14	21
Fitzhardinge et al. 1975	1970-72	19			26
Kumar et al. 1980	1974-77	50			14
Robertson & Etches 1988	1975-79	195			22
	1980-84	323			11

continued

Table 3. continued

< 1500 grams					
Harper et al. 1959	1952	54	24%	1	
Drillien 1961	1948-56	49	90%<100		53
McDonald 1964	1951-53	240		9	
Drillien 1967	1955-60	50	59%<90	28	56
Parmelee et al. 1970	1960	44	52%<90	23	32
Rawlings et al. 1971	1966-69	68	30%<90	7	13
Lubchenco et al. 1972	1949-53	133	43%<90	32	41
Drillien 1972	1966-70	40	13%<80	8	21
Wright et al. 1972	1952-56	67	46%<90	35	55
Stewart & Reynolds 1974	1966-71	95	8%<80	4	10
Francis-Williams & Davies 1974	1965-70	107	25%<85	0	2
Davies & Tizard 1975	1961-64	58	27%<85	12	2
Teberg et al. 1977	1964-70	136	23%<90 DQ	20	33
Black et al. 1977	1971-73	58	52%<70	7	35
Jones et al. 1979	1961-75	143			6
Peacock & Hirata 1981	1972-75	56	11%<90	25	25
Vohr & Coll 1985	1975	42			19
Calame et al. 1986	1972-76	83			12
Kitchen et al. 1987	1966-70	171			30
< 2000 grams					
McDonal 1962	1951-53	1081	3%<50	8	10
Parmelee et al. 1970	1960	120	38%<90	8	19
Douglas & Gear 1976	1946	69	6%ESN		
Commey & Fitzhardinge 1979	1974-75	71	42%<80	21	49
Drillien 1980	1966-70	231			8

DQ = Developmental Quotient
ESN = Educably Sub-Normal

Table 4

Summary of Follow-up Research for Decreased Gestational Age

	Gestational Age	Birth Date	N	I.Q. Defect	% Major Defect	% Total Defect
Parmalee et al. 1970	26-31	1960	36	50%<90	14	
	32-37	1960	101	41%<90	13	
Lubchenco et al. 1972	28	1949-53	33			64
	29-31	1949-53	35			54
	32-34	1949-53	23			30
Fitzhardinge et al. 1975	33	1970-72	67	13%<95	13	
Dargassies 1977	27-28	1962	29		31	
	29-30	1962	45		31	
	31-32	1962	88	9%<70	19	
	33-35	1962	67		16	
	36-37	1962	33		9	

(Data missing from the table were not reported in the original study.)

Although, due to variations in studies and small numbers of subjects, it is difficult to generalize findings, there is general agreement that disability is inversely related to birthweight and gestational age, and that prognosis is improving. In summary, few studies in the 1000 gram group were reported before 1960. It is unlikely that there were many survivors from this very low birthweight group before the 1960's. In the studies of the under 1000 gram group after 1960 the percent total defect ranged from 3% to 85%. Studies reported after 1970 rarely included the birthweight category 2000 to 2500 grams, which would seem to indicate that statistics for this group are stabilizing and quite favorable. Degree of deficit in the less than 1500 gram group has dropped markedly in births occurring after 1960. Low I.Q.'s were reported in approximately 50% of the group born before 1960 and 25% of the group born after 1960. Many studies do not report below average I.Q. in disability statistics, but in every birthweight group a large proportion of the survivors are within the average I.Q. range.

Learning Disorders in the LBW Group

A significant number of low birthweight children within the normal I.Q. range have been found to experience learning difficulties that require special class placement, special programming or repetition of grades. Much of the literature refers to populations that would be termed learning disabled, however, this label is often not employed. Lubchenco and her colleagues (1963) reported on 133 children of birthweights less than 1500 grams, born during 1949 to 1953 in

Colorado. At ten years of age, 57% had I.Q. scores greater than 90, but 50% of this group had difficulties with school work.

Focusing on the average group, DeHirsh, Jansky, and Langford (1966) completed thorough assessments on 53 children less than 2500 grams at birth and 53 who were born at full birthweight (FBW) in 1955 and 1956. They included only those for whom English was the predominant language in the home, no significant sensory deficits were evident, I.Q. scores were within one standard deviation of the mean of 100 on the Stanford Binet, and there was no evidence of psychopathology as judged clinically. Three sets of tests were administered — at the end of kindergarten, first grade and second grade. The LBW group scored lower than the FBW group on 36 of 37 subtests at the kindergarten level. Fifteen subtests produced statistically significant differences. Of the 15, 11 were oral language and reading readiness tasks, tasks that required a relatively high level of integrative competence. On all academic measures in grades one and two the LBW group performed significantly less well than did the FBW group. Because the LBW group performed more poorly on I.Q. tests, the I.Q. range was restricted to 90 to 105 for further analysis of achievement scores. The same trend remained evident with prematurely born children performing less well than controls on all but one measure, however, statistical significance was obtained on only three — activity level, Bender Gestalt, and grade two reading.

Drillien (1967) also investigated the academic performance of LBW infants at that time. She reviewed the psychological profiles of 50 children born at less than 1360 grams in Edinburgh form 1955 to 1960. She reported I.Q. scores of less than 90 in 59% of the group, but poor performance in school in 68% and behavior problems in at least 43%. The more recent work of Drillien, Thomson, and Burgoyne (1980) produced similar results. They followed a group of 261 children less than 2000 grams at birth, born 1966 to 1970. At age six years, eight months, 77% had I.Q. scores above 90 on the WISC, but only 66% were functioning low average or better in school. Ten percent of the group were uneducable in normal school and 24% were experiencing difficulties requiring special programming.

Kitchen, Rickards, Ryan, McDougall, Billson, Keir, and Naylor (1979) examined 158 long term survivors of birthweight 1000 to 1500 grams born in Melbourne between 1966 and 1970. At age eight years the average full scale I.Q. on the WISC-R was 89. Fifty-four percent of the group were in the I.Q. range above 90, but only 36% were reading at the level expected for their age on the Neale Analysis of Reading Ability.

Noble-Jamieson, Lukeman, Silverman, and Davies (1982) compared the psychological test results of 23 VLBW children with 23 controls matched for sex, age, and socio-economic status at 9 years of age. All were born at Hammersmith Hospital, London between 1968 and 1975. All were in regular school programs and without major disabilities. A short form of the WISC-R including Similarities, Vocabulary, Arithmetic, Block Design, and Object Assembly was administered as well as the Schonell Graded Word Reading List and a Children's Behavior Questionnaire. The pre-term children scored within the average range, but significantly lower on all

WISC-R subtests but Similarities. Highly significant group differences were found favoring full birthweight on the reading test, but non-consistent patterns or differences were found on the behavior scales.

Hunt (1981) followed 72 children less than 1500 grams at birth, born in San Francisco between 1965 and 1975. At four to six years of age the Stanford Binet Intelligence Scale was administered, as well as a group of tests to assess specific abilities -- visual-motor integration, language, and academic skills. The subjects were rated as normal, suspect, or abnormal, according to results of the specific tests. Disabilities occurred across much of the I.Q. range, in 46% of the group. In the normal and above I.Q. range (84 to 140) disabilities were found in 28% of the group. At age eight years, 30 of the 72 were reassessed. As the skill level of the tests became more complex, the number of disabilities increased. Twelve children with disabilities at age four to six years remained in the disabled category. Of seven with suspect disabilities, four remained suspect, two were classed as normal, and one showed signs of disability. In the group of eleven normal children, four remained normal, six were suspect, and one was disabled.

Longitudinal follow-up studies, such as this, suggest that unexpected problems may continue to occur as late as eight years of age. Rubin, Rosenblatt, and Balow (1973) found that there was a considerable increase in the incidence of abnormalities in children of low birthweight between the first year of life and the age of seven. They felt that this may reflect the increased range of behavior which may be tested in older children. Acting upon this possibility, several studies have either examined the psychological test results more closely or tested more extensively in an attempt to explain the learning difficulties specific to the LBW group. Wiener, Rider, Oppel, and Harper (1968) determined, from their extensive follow-up of 500 children of birthweight less than 2501 grams and 492 full birthweight children at eight to ten years of age, that perceptual-motor disturbances, flaws in comprehension and abstract reasoning, perseverative trends, poor growth in motor development, immature speech, and impaired I.Q. significantly identified LBW children. Apparently the effectiveness of the discriminatory power of these measures is in the order listed.

Hunt, Tooley, and Harvin (1982) examined ratings for language comprehension as well as visual-motor integration skills on an unspecified battery of tests. In their population of 67 six-year-old VLBW children born in San Francisco, 33 or 49 percent had one or both disabilities. Twenty-five had language comprehension problems, 20 had visual-motor integration problems, and 12 were found to have both. Of the children with neither problem, 5 had other difficulties such as distractibility or poor impulse control.

Perceptual-motor abilities have been isolated as a major deficit area in other studies. Vohr and Coll (1985) followed 42 VLBW subjects born in 1975 in Rhode Island. Results indicated that despite IQ's in the normal range (greater than 80) at 7 years of age in all but four of 42 children, there was an increased incidence of learning problems and visual motor integration difficulties as measured by the Beery

Developmental Test of Visual-Motor Integration and the Block Design subtest of the Wechsler Intelligence Scale for Children-Revised.

In a ten year follow-up in Chicago, Wright and his colleagues (1972) examined 65 survivors of birthweight less than 1500 grams and 65 paired controls. All were born between 1952 and 1956 and were examined at ages ranging from nine to fourteen years. On the WISC, 46% of the VLBW children obtained I.Q. scores of less than 90, while only 8% of the controls did so. Review of school performance was based upon reports from parents and teachers. In the VLBW group 19% of those with I.Q.'s above 90 were experiencing learning problems. In controls 10% had such difficulties. A more detailed analysis of the WISC results indicated there was a very significant superiority of control over LBW scores for the verbal and performance scales analyzed separately with a greater difference noted on performance scales. Poorest scores for the LBW group were on the Vocabulary subtest and on tests involving spatial orientation -- Object Assembly, Block Design, Picture Completion, and Picture Arrangement.

Similar results were found by Taub, Goldstein, and Caputo (1977). They assessed 38 children from a one year sample of 137 subjects of birthweight 1687 to 2500 grams. Those chosen were free from physical defects. Twenty-six normal birthweight children were also seen. Mean age of assessment was eight years. WISC-R data yielded significantly lower mean scores both for Performance I.Q. and for several Performance subscales for the LBW group. Block Design, Object Assembly, and Picture Completion produced the greatest differences. Results of the Bender

Gestalt test of visual motor integration were similar. Taub and associates concluded that, in the cognitive area, the relative deficits of LBW children more definitely involved visually mediated and particularly visual-motor functioning rather than spheres of functioning which are more characteristically verbal or auditory in character.

Klein, Hack, Gallagher, and Fanaroff (1985) eliminated, from their study, children with known neurological abnormality and below normal intelligence on the Stanford-Binet Intelligence Test (IQ<85). Forty-six nonhandicapped children who were VLBW infants, born in 1976 in Cleveland, were matched by race and sex with 46 full term classmates in kindergarten. A battery of educational tests, including the Slosson Intelligence Test, the Woodcock Johnson Psycho-educational Battery Preschool Scale, and the Beery Developmental Test of Visual Motor Integration, was administered to all children at age 5 years. Intelligence did not differ significantly between groups, however, significant differences were found on the Spatial Relations subtest of the Woodcock Johnson Battery and on the Beery Test of Visual Motor Integration - both measures of visual-motor and visual-perceptual function. On subtests that measured auditory skills no significant differences were found between groups. It was suggested that the greater vulnerability of the visual system may be explained by the fact that the maximal phase of maturation of the visual cortex occurs during the third trimester whereas the auditory system matures earlier.

In Lausanne, Switzerland, somewhat different findings were reported (Calame, Fawer, Claeys, Arrazola, Ducret & Jaunin, 1986). Follow-up of

73 nondisabled VLBW children, born during the period from 1972-1976, at approximately 7 1/2 years of age, revealed that language disorders were the most frequent abnormalities found, consisting mainly of various expressive language disorders. School failure was found in 50% of the 16 VLBW subjects with language disorders. In contrast, only 1 child of the 7 with visual-motor or fine and gross motor disorders had school difficulties.

In Montreal, examination of 32 AGA children over five years of age who were born during 1960 to 1966 with birthweights under 1251 grams, revealed similar findings (Fitzhardinge & Ramsay, 1973). Seventy-two percent had I.Q. scores over 90 on the WPPSI or WISC, but only 57% reported satisfactory progress in school. Wide discrepancies between Verbal and Performance scores were a common occurrence with 63% of the Wechsler tests showing a greater than 10 point difference. In 71% of the cases, the Verbal score was lower than the Performance, however, 28% of the group with normal I.Q. scores had evidence of perceptual motor difficulties measured by the Bender Gestalt and the geometric design subtests of the Wechsler and/or signs of minimal brain dysfunction determined from soft neurological signs.

Auditory-language or verbal difficulties had also been described by Wiener (Wiener et al., 1969). Among his large population of nearly 500 LBW subjects, one of the major problems described as 'behavioral' was reduced ability to comprehend instructions. Wright and associates (1972) were more emphatic about language related problems in their population. They found that the most outstanding difference between

VLBW and control subjects at school age was the relative inability of the premature group to express themselves well. Nearly one-third of them failed to develop speech, retained infantile speech patterns, or had difficulty with verbal organization.

Behavior Problems in the LBW Group

Various forms of maladaptive behavior have been investigated in follow-up of LBW infants. Lack of concentration, particularly as related to hyperactivity, confusion, and disorganized behavior was the most frequent of behavior disorders noted by Pasamanick, Rogers, and Lilienfeld (1956). The major disorders described by teachers in Drillien's 1961 VLBW sample also included lack of concentration (43%), as well as insecurity (30%) and immaturity (20%). Less frequently reported problems were nervousness, shyness, passiveness, and aggressiveness. Only 22% of the sample were considered to be free of behavior problems at school age. In her 1967 study, 39% of the subjects had problems of concentration while 43% were considered to be immature. Insecurity, shyness, and aggressiveness continued to be present, but in lesser degrees. Drillien further investigated behavior problems in 1980, but at this time employed a teacher checklist, the Bristol School Adjustment Guide, and included children up to 2000 grams at birth. Results of this study indicated that 25% of the group in regular school continued to demonstrate unsettled or maladjusted behavior.

Other studies have found similar patterns of behavior. Knobloch and Pasamanick (1960) and Robinson and Robinson (1965) reported that children who had been LBW infants tended to be aggressive, impulsive, distractible, hyperactive, inattentive, irritable, and disorganized, even in the absence of any distinct neurological or intellectual deficit.

Wiener's population of nearly 500 LBW children were found to be significantly more impulsive than full birthweight controls, as in previously reported work, but he also isolated perseverative trends and overly concrete thinking as characteristic of the LBW group (Wiener et al., 1968). Other behavioral characteristics which occurred with significantly greater frequency among the LBW group were reported in Wright's study (1972) including sleep disorders, destructiveness, and difficulty in relating to other children before entering school.

Black, Brown, and Thomas (1977) found the problems most commonly encountered by parents and/or testers were overdependency and shyness. From informal discussion with the parents it appeared that these difficulties resulted from the parents unwittingly reinforcing inappropriate behaviors. It seemed that parents had too often given in to the demanding behavior of the children probably because of an early tendency towards overprotection.

Bjerre and Hansen (1976) found an overprotective attitude in significantly greater numbers of parents of the LBW group. These children lacked confidence and were defiant toward their parents.

The behaviors described in these studies seem to fall into two categories. One group includes those behaviors commonly described in the cluster of characteristics defined by the term hyperactivity in the literature on learning disabilities -- overactivity, distractibility, short attention span, impulsivity, social immaturity, and poor social judgement (Farnham & Diggory, 1978; Richey & McKinney, 1978; Ross & Ross, 1976; Ullman, Egan, Fieder, Jerenec, Pliske, Thompson, & Doherty, 1981; Wender & Wender, 1978). Lubchenco (1976), in recognition of this fact, suggested that hyperactive behaviors were typical of the LBW population when the state appears in conjunction with soft neurological signs and perceptual-motor problems to form a cluster of abnormalities common to minimal cerebral dysfunction.

The second category of behavior disorders seem to be more closely related to maternal handling. Improper family management, common among LBW families, was described by Drillien (1964) as overanxious and rigid, indulgent and permissive, or variable and involving lack of control. The most common problem among mothers in the highest social classes was overanxiety and was especially frequent when infants' birthweights were less than 2040 grams. In the poorer working class homes, adverse handling took the form of physical neglect or permissive or variable attitudes.

Influence of Socio-economic Status on Long-term Prognosis

The severity of disorders in LBW children depends not only upon the extent of initial brain damage, but also upon the child's inherent potentialities and the effects of subsequent life experiences, however, the dynamics of the interaction of initial deficit, genetic potential, environmental effects, and intellectual and academic outcome are not well understood. While early mother-infant interaction cannot change organic brain damage, the adaptation of the child to his environment and handicap may be greatly influenced by his relationship to his mother and social situation. Improved functioning may occur naturally to some degree in a supportive, stimulating environment, whereas an increased risk for handicap may occur with LBW infants reared in poverty, a condition that is already at high risk for intellectual problems (Samaroff & Chandler, 1975). An added complication is the fact that an increased rate of LBW children may be found in the lowest socio-economic classes (Birch & Gussow, 1970). The actual birthweight and the future outcome may both be influenced by factors present in early pregnancy.

Two large longitudinal studies focussed on the relationship between prenatal and perinatal variables, general cultural and economic conditions of rearing, and later outcomes for children -- Werner's Kauai study (Werner, Bierman, & French, 1971; Werner, Simonian, Bierman, & French, 1967; Werner & Smith, 1977) involving the entire cohort of 698 infants born on the island of Kauai, Hawaii in 1955, and the National Collaborative Study, which involved the collection of detailed prenatal and birth record information on over 52,000 births from 1959 to 1965 in 12 university affiliated hospitals across the United States (Broman, Nichols, & Kennedy, 1975). Early results from these studies pointed to two basic conclusions about the relationship between perinatal status and later childhood outcome. Firstly, perinatal status variables such as low birthweight or anoxia had demonstrable relationships with later poor cognitive or motor development. Secondly, the effect of perinatal status variables appeared to be mediated by the quality of the environment in which the child was reared. Data from both the Kauai study (Werner, Simonian, Bierman, & French, 1967) and the Collaborative study (Willerman, Broman, & Fiedler, 1970) indicated that infants who had experienced high levels of perinatal complications showed poor cognitive functioning later primarily if they were also reared in poverty level environments.

These conclusions have been reiterated in research specific to the LBW population. Investigating the social class structure of their LBW children, Eaves, Nuttall, Klonoff, and Dunn (1970) found that 75% were in the lower two classes when rated one to five. However, socio-economic status did not alone account for the observed differences in the performance of children of LBW compared with those of FBW. Significant differences were found within the social classes with FBW children scoring significantly better on psychological measures than LBW children in the same social class, however, when measures were calculated for each social class the children in the higher social classes scored consistently better. Differences were greater in the lowest social classes than in the highest suggesting that the effect of social class may compound the difficulty which children of LBW experience.

Drillien, Thomson and Burgoyne (1980) found the social class distribution of their population to differ from that of Eaves, Nuttall, Klonoff, and Dunn (1970). They divided their population into four classes: 1) middle class 2) superior working class with child rearing and aspirations similar to middle class 3) average working class 4) poor working class with standards of care and management well below acceptable levels. Of 261 children, 47% of those less than 1500 grams at birth were reared in class 1 and 2 homes. Those of birthweight 1500 to 2000 grams did not differ significantly in social class distribution. In both LBW and control groups, tests of intelligence and educational achievement showed a marked decline in score and grading between the best homes and the worst. In the control group, differences by social grade were not statistically significant for perceptual skills, speech, or behavior, however, social class 4 in controls had small numbers which may have masked disturbed behavior in control children. In the LBW group, social class did not significantly affect motor ability or speech. In all other areas of functioning tested, the differences in performance between children reared in social class 1 and 2 and in social class 4 homes were highly significant statistically. LBW children scored consistently poorer than control children of like social class, but, contrary to other studies, the disadvantage of LBW as compared with controls was more obvious in children from middle class homes than it was in children from poor working class homes, where presumably, the researchers explained, the effect of low birthweight itself was diluted by the effect of environmental disadvantages common to both LBW and control children. It is also possible that adverse perinatal factors, including LBW were more common in control children from poor working class homes as information about perinatal status was not available for the controls.

Other studies have implicated socio-economic factors as determinants of outcome through correlations. Kitchen, Ryan, Rickards, McDougall, Billson, Keir, and Naylor (1980) found a strong correlation between unsatisfactory outcome, defined as low IQ, reading retardation, and neurological or sensory impairment, and socio-economic status as measured by the seven point Congalton Scale in their population of 169 VLBW children. Klein, Hack, Gallagher, and Fanaroff (1985) included maternal education with social class as strong correlates with Stanford Binet Intelligence, Slosson Intelligence and Beery Visual-Motor Integration scores in a group of non-handicapped VLBW children.

Wiener, Rider, Opel and Harper (1968) did not find interactions between birthweight and socio-economic status. In their study, effects of birthweight on psychological measures were similar in each social class group and each race. In all cases decreased birthweight was associated with impairment in a variety of skill areas. Details of the analysis of data concerning social class were not reported in the paper.

Siegel (1982) stressed that developmental outcome could not be determined by considering either factor, the biological or the social, in isolation. In developing a risk index predictive of intellectual functioning she considered reproductive, perinatal, and demographic variables. Her work with 42 VLBW children and 44 full-term, demographically similar children suggested that perinatal and reproductive factors were significant predictors of perceptual skills and development; and environmental factors were most important in predicting general cognitive and verbal scores, but that reproductive factors were also predictive in this area.

Problems Related to Gender of the Child

In addition to the relationship of outcome to birthweight and social class, it has also been shown that mental development and early educational achievement are correlated with the gender of the child in different studies.

In Drillien's early work (1967) there was a preponderance of females (64%) in the survey sample, which appeared to be due entirely to the increased chance of survival of female infants compared to males of similar birthweight. In addition, females were less often handicapped than males. Incidence of disability was 50% and 63% respectively. When complications of pregnancy were present, the percent of handicap increased, but at a markedly greater rate for males at 85.7% compared with 47.1% for females.

Of 240 LBW children followed in the 1980 study (Drillien, Thomas, & Burgoyne, 1980) similar results were evident. Fifty-eight percent of those attending regular school were female; transient neurological abnormality, possibly prognostic of later learning disabilities, was detected more often in boys (51%) than in girls (38%); and among neurologically normal LBW children, male sex appeared to confer a definite disadvantage with the boys (but not the girls) significantly inferior to control boys on most tests of achievement at age 6 1/2 years. Degree of general impairment was significantly greater in neurologically normal LBW boys (61%) compared with girls (35%).

DeHirsh, Jansky, and Langford (1966), limiting their study to LBW children free of sensory deficits and psychopathology, and within the normal I.Q. range, also found that the girls performed better than the boys. This was most evident on measures of school achievement -- reading, writing, and arithmetic at the end of grades one and two. Likewise, Eaves, Nuttall, Klonoff, and Dunn (1970) found significant differences favoring girls on all measures, including the Stanford Binet Intelligence Scale, the Vineland Social Maturity Scale, and a Block Sort task, at age 2 1/2 to four years in the LBW group.

Slight differences in average I.Q. were found by Fitzhardinge and Ramsay (1973) in a group of VLBW children who were appropriate for gestational age. Average I.Q. for boys was 88, average for girls 92, however, in reviewing school performance only 47% of the boys compared with 75% of the girls attained satisfactory performance in school. Those found to be failing in regular class or requiring special class placement included 40% of the boys and the remaining 25% of the girls. Thirteen percent of the boys were in institutional placement, while none of the girls were so placed.

Rubin, Rosenblatt, and Balow (1973) on the other hand, found no statistically significant differences between the sexes in a LBW population on measures of intelligence (Stanford Binet at four years and WISC at seven years), language (ITPA at five years), school readiness (Metropolitan Readiness Test at five years), or achievement (Wide Range Achievement Test at seven years), however, LBW boys accounted for a higher proportion of school identified educational problems than did the girls of similar birthweight. Proportion of repeaters, special class placements, and recipients of special services in the LBW groups were all greater than the proportion of control subjects in these areas. The differences between groups were largely attributable to the high proportion of LBW males who had received special services, were in special classes, or had repeated grades. There were no significant differences for females.

Hunt (1981) assessed intelligence, visual-motor skills, language ability, and academic achievement in the VLBW group. Again significant sex differences were not found in the incidence of handicaps. In the male population, 50% experienced disabilities described by the measures of specific skills. Forty-two percent of the females had disabilities, however, outcome for girls was more favorable in terms of severity -- 80% of those in the retarded range of intellectual functioning were male, while in the entirely normal group 67% were female.

Results of these studies suggest that LBW males constitute a particularly high risk population in terms of eventual impairment of school functioning. It may be that there exists a greater vulnerability on the part of the male organism to the stresses attendant upon premature birth.

Retrospective Studies of Learning Disorders

Systematic retrospective studies of birth trauma have lead to a focus on abnormalities in the birth process as a major factor in learning disorders.

Approximately 9% to 12% of all surviving new born infants manifest evidence of intracranial hemorrhage at birth (Coletti, 1979). When all other sources of potentially significant forms of brain insult are included, it is not unreasonable to estimate that by the sixth year of life, when formal learning begins, about 15%, or one in every six or seven children, have a history of potentially significant neurological abnormality that may be reflected at some later time in varying degrees.

The relevance of minimal brain damage or neurological impairment is given strong support by the findings of Pasamanick and his co-workers (Kawi & Pasamanick, 1958, 1959; Knoblock & Pasamanick, 1966; Pasamanick & Lilienfeld, 1955) who have demonstrated a high incidence of prenatal and peri-natal complications in the histories of children with learning disorders. The incidence of birth difficulties resulting in possible neurological impairment has also been observed by Strauss and Lehtinen (1947), Strauss and Kephart (1955) and Stott (1962, 1964). Black, (1973) and Davie, Butler, and Goldstein (1972) specifically related birth difficulties to backwardness in learning to read.

In a series of comprehensive retrospective studies, Pasamanick and Knoblock (1961) expanded the range of deviant developmental outcomes thought to result from minor central nervous system dysfunction caused by damage to the fetus or newborn child. Their results led them to propose a continuum of reproductive casualty, referring to a range of motor, perceptual, intellectual, learning, and behavioral disabilities. Five disorders were significantly associated with greater numbers of complications of pregnancy and prematurity. These included cerebral palsy, epilepsy, mental deficiency, behavior disorders, and reading disabilities.

Lyle (1970) examined the relationship between prenatal, perinatal, and speech variables; and perceptual-motor and verbal factors in a group of retarded readers of normal intelligence aged between six and twelve years. He found that the incidence of neurological impairment related to perinatal factors was related to both perceptual motor and verbal difficulties in the retarded readers, but that birthweight correlated only with the perceptual motor factor related to reading ability.

Naidoo (1972) found no difference in the incidence of perinatal conditions or abnormal histories between her dyslexic and control groups, but neonatal problems occurred more frequently among the dyslexic boys. Although mean birthweight did not differentiate the groups, all six boys in her sample, who were premature by birthweight, were dyslexic. In the study of backward readers by Bell and Aftanas (1972), mean birthweight tended to be lower in the backward readers than controls, but the differences were not significant. In Rutter, Tizard, and Whitmore's 1970 study of the Isle of Wight children, low birthweight occurred almost twice as frequently in the retarded readers (12%) as in the control group (7%), although this difference fell just short of statistical significance.

Statistically significant findings were obtained in Hoffman's study (1971). He compared the case histories of 100 children with learning problems with the case histories of 200 children who demonstrated satisfactory school performance. The age of students in both groups ranged from seven to nineteen years. Both groups were from predominantly middle income families. Neither group included those who were known to be mentally ill or genetically defective. The major prenatal factor differentiating the two groups was difficult delivery, occurring in 25% of the failing students and in only 1.5% of the able students. Cyanosis, prolonged labour, blood incompatibility, and prematurity were the other prenatal factors showing a significantly positive relationship with learning difficulties. Among failing students, 55% had histories of one or more abnormality, while this occurred in only 4.5% of passing students. The ratio of boys to girls in the group of students with learning problems was five to one; in the group of successful students it was four to five.

Coletti (1979) investigated a group of 50 children referred to a centre for learning disabilities. Ages ranged from seven to twelve years. Seventy-six percent were males, 24% females. The students represented an economic cross section. Mean Full Scale WISC I.Q. was 100. Birthweight and other pregnancy and birth complications were recorded and their frequencies in the learning disabled group were compared with frequencies from the Collaborative Prenatal Study. Results indicated that children in the learning disabled group tended to have more problems at birth than the norm. Nationally, 85% of the population of newborns were 'well and healthy' whereas only 34% of the children in the experimental group were so termed. Various factors associated with pregnancy and delivery complications occurred in significantly greater degree among the learning disabled group, but low birthweight alone was not significant.

Results of Bale's study (1981) were contrary to this. The only significant difference between his good readers and backward readers was incidence of low birthweight. This comparison was made between 85 backward readers, all boys, of average or above average intelligence and a control group of 82 boys selected from the same classes as the backward readers to equate for curricula and teaching method. All were approximately 10 years of age. Details of prenatal, perinatal, neonatal, and postnatal factors were obtained through questionnaires. Perceptual, motor, and language abilities were assessed and the subjects were subdivided according to the severity of their problems. Among the group with a severe degree of disability, 26.9% were LBW. Those with a moderate degree of impairment included 9.5% of LBW. In the mild/nil impairment group, 4.2% were LBW, while the control group included only 1.2% of LBW.

Pre-school Identification of Learning Disabilities

The early identification of children with learning disabilities is a recurring theme in psychological and educational research. Early detection is a major challenge, but chief among the benefits is prompt remediation and avoidance of needless failure and the concomitant psychologically maladaptive behaviors that compound an already complex learning situation (Buktenica, 1971; Trehub, 1977). Identification of the learning disabled group is, however, a difficult task. A uni-dimensional, single-factor trait model of learning disabilities does not exist. There are general commonalities, but use of an encompassing label for the group does not mask the presence of extreme heterogeneity manifested in the kind and degree of severity of educational handicaps exhibited by the group (Epstein, Hallahan, & Kauffman, 1975).

Learning disabled (LD) children can be described by one or more of numerous characteristics. Some children present perceptual handicaps, others have language difficulties, while others display hyperactivity and problems of attention to relevant stimuli. Multiple etiologies or unknown causative factors may be present. Some learning problems seem to be genetically determined, while others may be the result of an early insult to the fetus or neonate (Mercer & Trifiletti, 1977).

The scope of the term 'learning disabilities' becomes obvious when considering the number of characteristics described as 'typical' of the LD syndrome or group of disorders. All definitions describe a very heterogeneous group. Clements (1966) defined the learning disabled as:

> "...children of near average, average, or above average general intelligence with certain learning or behavioral disabilities ranging from mild to severe, which are associated with deviation of function of the central nervous system. These deviations may manifest themselves by various combinations of impairment in perception, conceptualizations, language, memory, and control of attention, impulse, or motor function." (p. 9-10)

The U.S. congress has defined children with specific learning disabilities as:

> "...those children who have a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, which disorder may manifest itself in

> imperfect ability to listen, think, speak, read, write, spell, or do mathematical calculations. Such disorders include such conditions as perceptual handicaps, brain injuries, minimal brain dysfunction, dyslexia and development aphasia. Such term does not include children who have learning problems which are primarily the result of visual, hearing, or motor handicaps, or mental retardation, or emotional disturbance, or environmental, cultural, or economic disadvantage (Office of Education, 1976)." (p. 38-39)

The Alberta Government conceptualization of learning disabilities follows:

> "The term learning disabilities refers to anyone of a heterogeneous group of chronic disorders that may have, as its basis, either an identified or an inferred central nervous system dysfunction, whose disorders may be manifested by difficulty in one or more processes such attention and concentration, perception, co-ordination and planning. This results in a demonstrable weakness in language arts, math and/or social competence. Learning disabilities may affect anyone, however, if a student is underachieving relative to his learning potential and has no sensory impairment, no motor impairment, adequate learning opportunities and an adequate learning environment, then learning disabilities are considered the primary disabling condition" (Alberta Education 1986, p. 1-5).

In light of this diversity of conditions and characteristics the task of identifying those who are at risk for developing learning disabilities is one requiring a broad base of knowledge about the children and a flexible outlook to diagnosis.

Ideally, pre-school screening procedures should be two-fold. Firstly, the assessment must be sensitive to the group at risk for developing learning problems without misclassifying those who are normal learners. Considerable difficulty arises from the fact that specific learning disability is primarily an academic handicap and as such is regarded as a mildly handicapping condition (Mercer, Algozzine, & Trifiletti, 1979). Mild handicaps are more difficult to detect early than are severe handicaps. Within the population the extreme ability groups, can be detected accurately; it is the range of milder disabilities (including the LD group) that are usually misclassified (Keogh, 1977; Satz & Friel, 1974, 1978).

The second concern of screening is the actual information provided. The assessment strategy should describe the child's learning characteristics, his unique strengths and weaknesses, his functional profile. This is necessary to determine appropriate instructional methods. If individualized programming cannot be operationalized from the information there is no useful purpose served in identifying the high risk group (Braggio, Braggio, Varner, Smathers, & Lanier 1980; Keogh & Becker, 1973; Mardell & Goldenberg, 1975).

Since school learning is not a uni-factorial skill and learning disabled children are not a homogeneous group, investigations of psychological factors in learning disabilities, aiming to identify the fundamental cognitive disabilities that are responsible for failure to learn, must tap a full range of learning processes. It is not surprising, therefore, to find that multiple instrument batteries or, at least multi-faceted measures, are being employed commonly in screening procedures. The range of abilities assessed is broad with some components, possibly the best predictors, appearing regularly in various batteries. Table 5 presents a summary of variables used in recent studies of assessment practices for identification of learning disabled children in the preschool period. Three general factors -- physical health, socio-economic status, and intelligence; and four more specific factors — impulse control, linguistic processes, visual processes, and memory; emerge from informal analysis of the items employed repeatedly in these studies.

By nature of the definition of learning disabilities, physical health, general intelligence, and socio-economic status are excluded as primary causal factors, but are often included in a learning skills assessment as their influence upon school performance has been established. Research relating the four specific processes to learning disabilities has produced inconsistent results.

Attention Deficit Behavior.

Specific kinds of task oriented, social and affective behavior are associated with good academic performance. The general portrait of a competent child is one of an attentive, independent, task oriented, socially appropriate child (Richey & McKinney, 1978). The cluster of behaviors characterizing attention deficit behavior -- distractibility, inattentiveness, impulsivity, and overactivity (Farnham & Diggory, 1978;

Table 5

Summary of Psycho-educational Subtest Items

Learning Characteristic	Adelman & Feshbach 1971	Becker & Snider 1979	Braggio et al. 1980	Colligan 1979	Eaves Kendall & Crichton 1972	Evans & Smith 1977	Feshbach Adelman & Fuller 1974	Ferinden Jacobson & Linden 1970	deHirsch Jansky & Langford 1966	Glazzard 1977	Haring & Ridgeway 1967	Lewis 1980	Lipson 1981	Mardell & Goldenberg 1975	Pihl & Nagey 1980	Rubin Balow Darle & Rosen 1978	Satz & Fletcher 1979	Satz & Friel 1974, 1978	Thorpe & Werner 1974
visual perception	x		x	x	x		x	x	x	x	x		x	x	x	x	x	x	
auditory perception	x				x		x		x	x	x			x		x	x	x	
visual attention span	x	x	x			x					x	x							
auditory attention span	x	x				x					x	x							
aud.-vis. integration																		x	
perc.-motor integration	x				x		x	x	x	x	x	x	x	x			x	x	x
L-R discrimination											x							x	
handedness											x							x	
directionality											x								
fine motor ability		x	x	x	x				x		x	x	x	x	x			x	x
gross motor ability		x		x							x		x	x	x			x	
body image						x		x			x		x	x					
general health	x										x								
sensory ability	x										x								
auditory comprehension	x	x	x	x						x		x		x	x	x		x	x
speech	x			x	x		x		x	x	x	x	x	x				x	
language	x		x	x	x		x		x	x	x	x	x	x	x		x	x	x
intelligence										x	x								
conceptual skills			x	x	x				x	x	x			x	x			x	
pre-academic readiness								x		x	x		x	x		x		x	
memory	x		x				x				x				x	x	x		
work habits	x	x				x				x		x			x			x	
impulse control	x	x					x					x			x		x	x	
emotional-social	x	x		x		x						x	x		x				x
socio-economic status																		x	

Ross & Ross, 1976; Ullman, Egan, Fieder, Jurenec, Pliske, Thompson, & Doherty, 1981; Wender & Wender, 1978) would, therefore, predispose a student to learning difficulties, even in the presence of intact learning processes.

It is the characteristic of distractibility, not hyperkinesis, that has been cited as the major behavioral dimension differentiating the learning disabled group from normal learners (Evans & Smith, 1977; Richey & McKinney, 1978). Distractors can be of a proximal or distal nature. Browning (1967) and Douglas (1972) found distal distractors, such as novel bright lights, colored objects, and loud noises, distracting to both learning disabled and normal children, but normal children were able to adjust more quickly to the distractors and were able to screen out subtler and more proximal distractors.

Keogh and Donlon (1972) compared groups they described as field dependents, those influenced by the perceptual field around them, and field independents, those not influenced by the context of the stimulus field. In their investigation, the learning disabled boys were found to be highly field dependent, regardless of the nature of the distractors.

Tarver and Hallahan (1974) reviewed studies requiring subjects to perform in the presence of proximal and distal distractors. There was general agreement that, as a group, the learning disabled children attend less well in the face of distracting information, particularly that near the material to be focussed upon. Low achievers also recalled more irrelevant stimuli, such as doodles on the page, colors, or extraneous background, than did high achievers.

Lasky and Tobin (1973) investigated auditory distractors. Their subjects were required to respond to questions about a worksheet, to make a written response to auditory questions, and to make a written response to written questions in the presence of three varying auditory circumstances. There was either no distraction, white noise, or background noise of children reading prose and number facts. On all three response tasks, learning disabled first graders did not differ from normal peers in quiet or white noise conditions, but the performance of the learning disabled group was adversely affected in the linguistic distractor condition, whereas the performance of the normal group was not.

Impulsivity is another characteristic often associated with poor academic achievement (Epstein, Hallhan, & Kauffman, 1975; Kaga, 1965; Messer, 1970). According to Kagan (1965, 1966), the impulsive child places a greater value on quick success than on avoided failure. In contrast, the reflective child demonstrates higher standards for mastering intellectual tasks and attempts to solve problems in a deliberate and correct way. Kagan and his colleagues (Kagan, Rosman, Day, Alberta, & Phillips, 1964) have also indicated that children who tend to respond impulsively are more apt to make unnecessary mistakes on school related tasks than children who are more reflective in their problem solving strategies.

Nagle and Thwaite (1979) compared 100 learning disabled children to 100 normal achievers on Kagan's Matching Familiar Figures test of impulsivity. By dividing the subjects into four groups, impulsive, fast-accurate, slow-inaccurate, and reflective they found no significant difference between the learning disabled and the normal population on cognitive style, but did find significant differences on error rate. The way in which information was processed differentiated the learning disabled group from the achieving group more effectively than the speed of processing. Studies of behavior modification of impulsivity found that latency time could be increased, but that accuracy did not improve without instruction in learning strategy (McKinney, 1978).

Overactivity, the characteristic most commonly associated with hyperactivity interferes with learning in two ways — it affects the amount of time spent attending to academic tasks and it elicits negative reactions from socializing agents (Ross &Ross, 1976). Stevens and Long (1973) showed video-tapes of a boy behaving in an overactive, average, and underactive fashion, to parents of elementary school children. At intervals screening was stopped and the parents indicated their reactions to the child. Of the four choices, two positive affective reactions, one negative affective reaction, and one disciplinary reaction, overactivity elicited significantly more disciplinary responses, deviations from the norm in either direction elicited more negative affect responses than did average activity, and positive qualities did not cancel out effects of overactivity.

Overactivity and non-compliance with demands for inhibition are sufficiently troublesome to parents that many seek psychiatric assistance. Wender and Wender (1978) have suggested that hyperactivity is the single most common behavior disorder seen by child psychiatrists and is one of the most common referrals to clinics for behavior problems.

McKinney (1975) and Kagan (1965) have described negative reactions of teachers to the classroom behavior of the hyperactive child. They have suggested, and not unreasonably, that most teachers do not have a high tolerance for inattentive, off-task, out-of-seat, restless behavior, particularly when accompanied by incorrect or inappropriate responses to classroom activities. If these behaviors are of an uncontrollable, driven nature, a disruption of the hyperactive child's learning environment is inevitable.

Linguistic Processes

Success in academic subjects is highly dependent upon facility with language processes. In fact, Vellutino (1977) has considered all other systems to be subordinate to language in acquiring the ability to read. Ingram, Mason, and Blackburn (1970) and Lyle (1970) reported that approximately one-half of the children referred to a clinic for reading problems had a history of speech and language difficulties.

Three levels of linguistic processing are important to the learning process -- phonological, syntactic, and semantic. At the level of phonology, also referred to as auditory discrimination, the sound system of the language is involved. Research suggests that a major difficulty encountered by poor readers is their limited ability to decode individual words and word parts (Calfee, Chapman, & Venezky, 1972; Shankweiler & Liberman, 1976). It is assessed in terms of segmentation and synthesis. Segmentation tasks require recognition of similarities and differences between sounds, detection of rhyming, and production of change in the phonemic structure of words. Synthesis tasks involve blending individually presented sounds into a syllable or word, or recognizing words presented with incomplete syllables.

Holinkoff (1978) presented extensive evidence regarding the importance of phonemic awareness in the reading process, its developmental nature, and its predictive relationship to reading achievement. Encouraging results of training phonemic awareness support the view that auditory perceptual skills bear a critical relationship to the acquisition of reading skill. Studies comparing disabled readers with good readers have reported better performance by good readers on both segmentation and synthesis tasks (Bartin, 1971; Bradley & Bryant, 1978; Doehring, 1968; Liberman, 1973; Naidoo, 1972).

Semantic processing involves the meaning of words and of sentences. Successful word identification depends upon, among other things, a child's ability to extract meaning from the words he reads or attempts to decode (Vellutino, 1979). This is true of single word identification as well as identification of words in context, and of strings of words. Perfetti and Lesgold (1978) found that poor readers had difficulty in naming a word stimulus and in retrieving semantic information in response to a name. Inefficiency in comprehending meaning was observed in the processing of spoken as well as written language. Following instructions and participating in general classroom discourse are hindered by difficulties in this area.

Studies have reported inconsistent results in comparing learning disabled with normally achieving students on measures of vocabulary, comprehension of similarities, and verbal analogies. Vogel (1974) did not find differences between good and poor readers in Peabody Picture Vocabulary scores whereas Satz, Friel, and Rudegeair (1974) found that disabled readers had a lower receptive vocabulary than good readers even when children with a Peabody score below 90 were excluded. Studies comparing good and poor readers on the WISC Vocabulary and Similarities subtests are limited by the IQ selection criteria. Studies matching good and poor achievers on Performance IQ tend to report significant differences (Doehring, 1968; Lovell, Shapton, & Warren, 1964), whereas fewer differences have been reported when subjects were matched on Full Scale IQ (Rugel, 1974).

Syntax pertains to the rules governing the arrangement of words in sentences. Studies of syntactic processing have found that, compared with good readers, disabled readers have difficulty applying morphological knowledge (Fletcher, Satz, & Scholes, 1981; Wiig, Semel, & Crouse, 1973). Apart from measures of vocabulary, which are specific to measuring understanding and meaning, general language tasks often provide information about both semantic and syntactic processing. A comparison of the oral language competence of normal and poor readers of similar age, sex, intelligence, and socio-economic status, found that normal readers were characterized by larger speaking vocabularies and greater fluency than the poor readers (Fry, Johnson, & Muehl, 1970). In this study, the normal readers' productions were also characterized by greater flexibility and more complexity in syntactical usage than those of the poor readers.

Tasks requiring the child to choose pictures in response to sentences of varying grammatical complexity also reflect both levels (semantic and syntactic) of linguistic skill and have produced varying results. Semel and Wiig (1975) found poor performance by learning disabled children on this task, whereas Vogel (1974) found no differences between good and poor readers. Learning disabled and normally achieving students differed consistently, however, on tasks requiring repetition of sentences of increasing grammatical complexity (Denkla, 1977; Doehring, 1986; Uattis, French, & Rapin, 1975; Vogel, 1975).

Visual Processes

The relationship between visual perceptual difficulties and learning disabilities is a topic of some controversy. Although analysis of the reading process indicates that an early essential skill is that of differentiation and identification of letter shapes (Vernon, 1979), research comparing good and poor readers on visual perceptual tasks has yielded inconsistent findings. Gibson and Levin (1975) suggested that a child learns the distinctive features of graphic stimuli in the early stages of reading. Visual perceptual skills may, therefore, be more highly related to achievement at younger ages, most likely less than eight or nine years of age (Satz & Friel, 1980). The specific nature of the task also appears to influence results. It is the measures involving visual analysis of detailed arrays, discrimination of complex strings of alphabetic and non-alphabetic stimuli such as embedded figures, rotated stimuli, lengthy sequences of stimuli, and left-right discrimination, that differentiate learning disabled and normally achieving children (Doehring, 1968; Satz, Friel, & Rudegeair, 1974; Taylor, Satz, & Friel, 1978). Tests involving discrimination of letters and words are better predictors of success in reading than tests involving discrimination of pictures and geometric designs, and measures requiring both visual discrimination and knowledge of letter names are better predictors than those requiring only letter matching (Samuels, 1972; Calfee, 1977).

A number of investigators have reported differences between the learning disabled group and normally achieving children on figure drawing tests such as Bender Gestalt Test or the Beery Test of Visual-Motor Integration (Jansky & DeHersch, 1972; Lowell, Shapton, & Warren, 1964; Lowell, Gray, & Oliver, 1964; Satz, Friel, & Rudegeair, 1974, 1976; Silver & Hagin, 1971). In contrast, other studies reported no substantial differences between the reading disabled and normal learners on visual-motor, and spatial orientation tasks such as Block Design and visual matching of geometric forms (Levine & Fuller, 1972; Rugel, 1974; Symmes & Rapport, 1972; Vellutin, Smith, Stager, & Kaman, 1975).

Kozzity (1975) compared two learning disabled groups, one with normal reading ability, but poor performance in other academic subjects, and a second group who were quite impaired in reading. She also assessed a control group of children who were achieving normally. The results did not differentiate the two learning disabled groups, but there were significant differences between these children and the normal achievers on this test. Visual-motor skills may be more closely related to overall school functioning and learning disabilities in general than to reading achievement uniquely.

Human figure drawings have also been employed as measures of visual-motor integration and general mental maturity. Colligen (1967) found children with learning difficulties produced drawings significantly different from normal achievers. Their human figures showed fewer characteristics of maturity, detail, and lifelikeness than drawings of achieving students. Dillard and Landsman (1968), Strahl (1972), and Szasz, Baade, and Pashewicz (1980) reporting on human figure drawings of kindergarten children, suggested that predictive information derived from these drawings depended mainly upon the totality of the child's development — the degree of integration of the mental, physical, and social dimensions evident in the drawings.

Memory

Retaining visual spatial patterns, recalling auditory temporal patterns, remembering auditory visual associations, and serializing this information correctly are aspects of memory that have been addressed in learning disabilities research.

Lyle and Goyen have conducted a number of studies evaluating the possibility of visual memory deficits in poor readers. Subjects were given brief presentations of letters, simple lines, and word shapes for immediate, delayed and sequential memory (Lyle & Goyen, 1968). Poor readers were found to be less accurate than normal readers under all three conditions. In another study (Lyle, 1968) poor readers were found to be less able than normally achieving students, aged 9 years, on the Graham-Kendall Memory for Designs Test. Poor readers also made more errors than normal readers in matching geometric forms to standards, with stimuli presented for brief exposures (.5 seconds) and under immediate and delayed (2 seconds and 7 seconds) recognition conditions (Goyen & Lyle, 1973). In contrast, Vellutino, Steger, DeSetto, and Phillips (1975) found poor and normal readers were comparable in visual memory for randomly arrayed Hebrew letters, whether presented immediately after initial exposure, twenty-four hours later, or six months later.

Research involving auditory memory is comprised primarily of tasks that are sequential in nature. Bakker (1972) compared normal readers with disabled readers on a temporal ordering task using sets of letters. The older subjects performed better than younger ones, the girls performed better than the boys, and poor readers did not perform as well as normals, nor did they improve their performance as much with age as did the normals.

Zurif and Carson (1970) compared samples of dyslexic and normal readers on a variety of temporal order tasks, including rhythmic patterns presented both auditorily and visually. Achievement correlated significantly with tests of temporal order recall -- the poor readers making more errors than normal readers.

Senf and Freundl (1972) also compared normal and disabled readers on auditory and visual sequential memory, using a digit span test. The performance of poor readers was below that of normals on item memory, but groups were not distinguished on memory and/or sequences. Increasing trial length more adversely affected the poor readers than the normal readers. Visual presentations produced more errors than auditory presentation, these effects being constant across reader groups.

Summary of Literature Review

With the introduction of neonatal intensive care units in major hospitals in the 1960's, survival rates of LBW infants have shown an encouraging trend, however, predictions were made that this would increase the number of disabled individuals entering society. Follow-up studies of LBW infants reported inconsistent outcome statistics on handicapping conditions. It is difficult to generalize from the findings since theoretical approaches differ, assessment techniques vary, methods of data presentation change from one study to another, the socio-economic composition of the populations served by the various treatment centres differs, and there is no standardization in antenatal and obstetric care. In spite of these differences, the direction of change in incidence of disabilities is positive. School performance tests suggest, however, that despite presumably normal intellectual development in a sizable proportion of the LBW population, problems in learning, reading, and behavior continue in this group. Perceptual-motor deficits have been isolated as a major problem in several studies, however, language difficulties have also been found to play a role in learning problems. Various forms of unsettled or maladjusted behavior may also contribute to school difficulties.

Various factors within the LBW population may influence outcome. The risks faced by the group of infants who are small for gestational age differ from those who are appropriate for gestational age, with a higher incidence of neurological and developmental handicaps associated with the small for gestational age group. Birthweight of less than 1500 grams is also associated with a higher incidence of handicaps than the birthweight classification of 1500 to 2500 grams. And, since it relates to maturity of the organism, gestational age per se affects outcome, even in the appropriate for gestational age group.

The interaction of LBW, inherent potentialities, and effects of subsequent life experiences associated with socio-economic status has been demonstrated as well. Although the dynamics of this interaction are uncertain, low socio-economic status seems to compound the difficulties experienced by a vulnerable infant. Long term prognosis is also associated with the sex of the child, with male sex conferring a definite disadvantage.

Retrospective studies of learning disorders have drawn similar conclusions about the influence of LBW, although other birth complications are also implicated. Causal links cannot be established, but LBW appears with significantly greater frequency in the case histories of learning disabled populations compared with successful students.

Taking this information into account may improve the efficiency of screening procedures for early identification of children who are at risk of developing learning disabilities. An understanding of the proportion of healthy survivors of VLBW who develop learning disabilities and the types of disabilities they exhibit should enhance such procedures. To provide the data, an assessment of various learning processes in the VLBW population is necessary.

A review of numerous studies of screening procedures for use with preschool children reveal three general factors affecting school performance -- physical health, socio-economic status, and intelligence; and four more specific factors — attention deficit behavior, linguistic processes, visual processes, and memory. Research relating the four specific processing factors to learning disabilities has produced inconsistent findings. This is due in part to sample heterogeneity, to questionable construct validity of some of the assessment tasks and to lack of control over IQ and socio-economic factors.

Research Questions

Previous research has indicated that disability is inversely related to birthweight and gestational age in the VLBW population. Since 1960, low I.Q. scores have been reported in 11% to 52% of the VLBW group. A large proportion of the survivors are, therefore, within the average I.Q. range. Unfortunately, a significant number of these intellectually average children have been found to experience learning disabilities requiring special class placement, special programming, or repetition of grades. There is uncertainty, however, regarding the incidence of the different types of learning disabilities in the VLBW population and the effects of various factors. Therefore, the following research questions have been formulated to provide more specific information concerning the learning profiles of a specific subgroup of children of VLBW.

1. Is there evidence of decreased functioning in a sample of VLBW children (who were appropriate for gestational age at birth and free from major handicaps at age 5 1/2 years) on a battery of subtests designed to measure learning processes presumed to be related to learning disabilities?
2. Does the performance of the VLBW sample differ from the performance of a comparable full birthweight (FBW) sample on these measures?
3. Is test performance of VLBW males different from test performance of VLBW females on the set of variables employed in this study?
4. Is test performance of the VLBW sample influenced by gestational age, birthweight or mother's age?
5. Is test performance of the VLBW and FBW samples influenced by socio-economic status, behavior, or IQ as measured in this study?
6. Which variable or variables best characterize the VLBW group?

CHAPTER III

Methodology

Background

The Neonatal Follow-up Clinic, located at the Glenrose School Hospital in Edmonton, was established in the summer of 1974 as part of the Northern and Central Alberta Perinatal Program. The primary objective of the Clinic is the evaluation of Neonatal Intensive Care through documentation of the quality of the cognitive, behavioral, and motor performance of the survivors. The Clinic provides an opportunity to record changing age-related abnormal neurological signs and developmental levels of children who are critically ill as newborn infants and to correlate the early abnormal findings with permanent disabling conditions or with normality. It is anticipated that this documentation will aid in determining more precisely which of the neonatal graduates are at risk for future developmental problems and which early signs of variation in development have long-term significance.

At the beginning of the study there were approximately 18,000 live births per year in Northern and Central Alberta Perinatal Program Region (Robertson, 1980). Of these, nearly 900 high risk children were treated in the Neonatal Intensive Care Units at the University of Alberta and the Royal Alexandra Hospital in Edmonton. About 250 of these babies met the criteria for admission to the Glenrose Neonatal Follow-up Clinic each year. The first 1000 babies born after August 1974 to meet the criteria were included in the follow-up study.

Neonates cared for in the Intensive Care Units who had predictably handicapping conditions such as known chromosomal, inherited, or intrauterine infectious disorders or malformations were not followed. Only those who were potentially normal were referred to the clinic. The babies were divided into several classifications including:

- infants weighing 1500 grams or less at birth
- infants weighing more than 1500 grams at birth with central nervous system conditions complicating their course of development
- infants weighing more than 1500 grams at birth, requiring ventilation, but without central nervous system involvement
- infants weighing more than 1500 grams with specific problems that did not fall into the previous classifications.

The children were first seen by Follow-up Clinic staff while in the Neonatal Intensive Care Units at the Hospitals and subsequent appointments were made for review and assessment at the Clinic at ages three, six, nine, twelve, eighteen, and twenty-four months, 3 1/2. 5 1/2, and eight years. Personnel from the departments of nursing and pediatrics assessed the children at each visit. The other departments, including Social Service, Occupational Therapy, Physio-therapy, Ophthalmology, Audiology, Orthopedics, Psychology, Speech Pathology, and Education assessed the children at various ages depending upon the appropriateness and necessity of the investigation. The Department of Education was involved on a regular basis at ages 5 1/2 and eight years.

Research Design

As this is the initial analysis of the 5 1/2 year VLBW data from the Neonatal Follow-up Clinic, a single specific subgroup has been isolated for investigation. Only those subjects who were appropriate for gestational age, non-handicapped at age 5 1/2, and equal to or less than 1500 grams at birth were included. This limited the generalizability of findings to this subgroup thereby increasing field validity of the results. A control group was not followed, however, a group of children representative of the normal population and matching the target group for age were included as a comparison group, but could not be described as a control group.

The design employed in this study is a non-experimental longitudinal design combining elements of the two group posttest design and the multiple group posttest design with multiple measures. The two independent variables for the main analysis were related to birthweight categories - either VLBW or FBW. Further analyses subdivided each birthweight category to investigate the influence of socio-economic status, gender, mother's age, IQ, behavior, and gestational age. These factors then became the independent variables. Random assignment of subjects to any of these groups was obviously not possible. The dependent variables included all measures in the multivariable test battery, excluding the Stanford Binet IQ or the David's Rating Scale for the specific analyses involving IQ or behavior as independent variables.

Subjects

The subjects in this study fell into two groups, a target group of very low birthweight (VLBW) and a comparison group of full birthweight (FBW). The VLBW sample consisted of children weighing 1500 grams or less at birth and meeting the criteria for inclusion in the Neonatal Follow-up Clinic population, Glenrose School Hospital. To this group certain restrictions were applied. Excluded from the study group were:

- children who were determined to be small for gestational age at birth, that is, children who were found to be below the 10th percentile on the growth curve for gestation age,

- children with physical disabilities including cerebral palsy of all types and severities, visual loss with the best corrected vision being visual impairment (vision less than 20/60), severe convulsive disorders, and neurosensory or mixed hearing loss with loss in the better ear of greater than 70 decibels,

- children with mental handicaps, with IQ scores, measured by the Stanford Binet Intelligence Scale, less than 70.

During the study intake period from 1974 to 1979, 543 infants, appropriate for gestational age and weighing 1500 grams or less, were admitted to the Neonatal Intensive Care Units at the Royal Alexandra and University Hospitals, meeting criterion for admission to the Glenrose Neonatal Follow-up Clinic. Data on 110 of these infants were available for inclusion in this study. The disposition of the 433 that were not included is outlined in Table 6.

Table 6

Disposition of VLBW Infants Treated in Neonatal Intensive Care

Total Admission to Neonatal Intensive Care Units $\leq$ 1500 grams (excluding Small for Gestational Age) = 505

Deaths		
In Hospital	271	
After Discharge	11	
	282	
Excluded from Analysis Due to Conditions Affecting CNS Outcome		
Wardenburg's Syndrome (Deafness)		1
Head Injury in Motor Vehicle Accident		1
Recurrent Hypoglycemia (Unconsciousness)		1
		3
Disabled at 5 1/2 years		
Cerebral Palsy		27
Mentally Handicapped (IQ<70)		4
Convulsive Disorder		1
Neurosensory Deafness		5
Blind		5
		42
Lost by 3 1/2 Years		23
Followed by Mail after 3 1/2 years		34
Not Yet Seen for 5 1/2 Year Assessment		11
Available for 5 1/2 Year Analysis as of June 7, 1984		110

The comparison group was drawn from four schools with large populations considered to be represenative of the range of socio-economic levels in the city of Edmonton. All schools were from the Edmonton Public System. In the spring of 1984 parental permission was obtained to assess 200 children, 4 1/2 years to 6 1/2 years of age, from ten kindergarten classes. Three of these children were not assessed as one was too young and two others were found to be of very low birthweight. The remaining 197 children comprise the full birthweight category (greater than 2500 grams at birth).

Instruments

The construction of the test battery was limited by the need to confine the testing to one session and to avoid undue fatigue or distress to the young subjects. Limited access to parents was also a factor in chosing instruments. The measures were chosen to assess intelligence and levels of functioning in the five areas determined, in the literature review, to be predictive of learning disabilities - intelligence, attention deficit behavior, linguistic processes, visual processes, and memory. An index to rate socio-economic status of the family was also selected.

Of the well established intelligence tests, the Stanford Binet Intelligence Scale (Terman & Merrill, 1972) was selected. It was necessary to chose a measure with norms that would extend downward, well below 5 years of age, as it was expected that a certain proportion of the VLBW sample would have limited cognitive ability. The standardization sample included 4498 subjects, aged 2 1/2 to 18 years, from 6 different states across the United States. The norming was completed during the years 1956 and 1957. Validity measures of test items evaluated the degree to which a regular increase in mental age from one age to the next agreed with increase in percent passing from one chronological age to the next, as well as the degree of correlation with the total score. The mean correlation of test items with the total score is .66. At the preschool levels, 2 1/2 through five years, the mean is .61; for years 6-0 through 14-0 the mean is .67. The adult levels have the highest correlation at .73. Verbal tests indicate higher validity than non-verbal.

The Goodenough-Harris Draw-a-Man Test (Harris, 1963) was also included as a measure of mental maturity since administration is brief, it is an enjoyable task for most children of five years, and it does not require a verbal response. Quality of production is scored, but receives far less weight than the elements of the composition. The resulting score is a standard score with a mean of 100 and a standard deviation of 15.

Norms were established on a standardization sample of 2,975 children between the ages of 5 and 15 years representative of the occupational distribution of the United States in 1950 and distributed among four major geographical areas. Scorer reliabilities are usually over .90 reflecting the fullness of the scoring instructions and the care in selecting items that can be scored with a minimum of uncertainty.

The Davids Rating Scale for Hyperkinesis (Davids, 1971) was selected as a measure of behavior problems manifested by many children who are at risk for educational difficulties. This measure was chosen because the very clear definitions provided for each of the six questions greatly increase the reliability of rating by different sources. It was also non-treatening in appearance as it is very brief. The child's behavior was rated, on a 6-point scale, by the parents of VLBW Subjects and teachers of FBW Subjects on each of six traits - hyperactivity, attention span, variability, impulsiveness, irritability, and explosiveness. The examiner assisted with all behavior ratings to further increase reliability. The scale produced raw scores that could be grouped into one of three categories--less than 19 indicating no problem, 19 to 23 described as suspicious, and 24 to 36 indicating the possibility of hyperkinesis. No norms were employed. A copy of the instrument is included in Appendix J.

The Metropolitan Readiness Tests, Form P, Level 1, (Nurss & McGauvran, 1976) were chosen to measure various pre-academic skills including:

1. Auditory Memory. This subtest measured the pupil's immediate recall of a series of words spoken by the examiner. It also involved the ability to associate sounds with visual symbols.

2. Rhyming. The ability to hear and discriminate among medial and final sounds in a rhyming context was measured.

3. Letter Recognition. This subtest examined the ability to recognize both upper and lower case letters. Recall of information was assessed, as well as visual discrimination.

4. Visual Matching. Visual-perceptual skill in matching letter series, words, numerals, and letter-like forms was assessed.

5. School Language and Listening. In this test, basic cognitive concepts, as well as comprehension of simple and complex grammatical structures, were measured. The items designed to test listening comprehension require pupils to integrate and reorganize information, to draw inferences, and to analyze and evaluate material presented orally.

6. Quantitative Language. This subtest measured an understanding of certain basic quantitative concepts such as size, shape, and number-quantity relationships, in an oral language context.

The raw scores could be given a rating of low, average, or high compared with scores of other kindergarten children.

A total of 68,997 subjects from various ethnic groups and geographical regions of the United States participated in the standardization program. A stratified random sampling process was employed to select the 191 school districts for the fall norming and 260 districts for the spring norming program. Validation studies were designed to determine the relationship between the Metropolitan Readiness Tests and the Metropolitan Achievement Tests, 1970 edition. A group of 719 subjects participated in this study. Correlations ranged from .41 to .72. Test-retest reliability was high with correlations of

.93 and .95 for Pre-reading Composite Scores. Subtest correlations ranged from .73 to .88.

The Detroit Tests of Learning Aptitude (Baker & Leland, 1967) is a flexible instrument, adapted to examine skills from pre-school to high school. The standardization procedure for this measure appears to be inadequate. The mental age norms and order of difficulty of individual items were determined using 50 average children for each age level. A reliability of .959 was reported on 48 cases retested after an interval of 4 to 5 months. A correlation of .91 with the Stanford Binet Intelligence Scale was reported for 32 cases, however, the age ranges were not stated.

The complete battery of 19 subtests from the Detroit Tests of Learning Aptitude yields a general mental age, but administration of selected subjects to provide specific information is encouraged. Two subscales from the Detroit were selected:

1. Pictorial Absurdities measured reasoning, comprehension, and visual attentive ability in determining what is foolish in a series of pictures.

2. Auditory Attention Span for Related Syllables measured auditory attentive ability and verbal skills, as the child must recall sentences of increasing complexity. Scores from these subscales were recorded as age equivalents.

The Wepman Auditory Discrimination Test (Wepman, 1975) was chosen as a measure of auditory perception. This test examined recognition of similarities and differences in initial, medial, and final sounds in 40 trials. Results were summarized on a 5 point descriptive scale with 3 as average.

The standardization was completed on 1000 children ages five through 8 years. It confirmed the developmental nature of the test with increasing median test scores at each age level. The test-retest reliability coefficients were .91 (N=109) and .95 (N-279), however, detailed information on this study was not provided. Validity studies reported in the manual indicated that a significant difference was found, at the .01 level, comparing the performance of a group of first grade students with speech articulation difficulties with students without such speech difficulties. Significant correlations at the .01 level were reported between this test and each subtest of the Metropolitan Achievement Tests.

The Peabody Picture Vocabulary Test (Dunn, 1965) was selected to provide an estimate of verbal comprehension and verbal intelligence through receptive vocabulary. The subject was required to chose one of four pictures to illustrate the meaning of a word presented orally by the examiner. The test provided age equivalents, stanines, percentiles, and standard scores. Percentiles were employed in this study.

Standardization was based on 4,012 white children in and around Nashville, Tennessee. Students were chosen from schools where previous IQ scores provided a normal probability curve or random samples were drawn until the available IQ scores approximated normal distribution. Numbers ranged from 92 to 354 at 19 different age levels from 2.5 years to 18 years. No test-retest reliability is reported in the manual. A review by Piers (1965) reported a test-retest correlation coefficient of .88 after one year with 29 physically disabled students. She summarized validity studies as well as reporting correlations with Stanford Binet mental ages in the order of .70's and .80's with IQ correlations running lower. Correlations with WISC IQ's were in the same range.

The Developmental Test of Visual-Motor Integration, the VMI, (Beery, 1967) measured the integration of visual perception and motor co-ordination. A series of 24 geometric forms were to be copied with a pencil and paper. The forms were arranged in order of increasing difficulty to be administered to children in the age range of two to fifteen years, but it was designed primarily for preschool and early primary grades. This was extremely important as norms in the age range below 5 years were necessary. The resulting score was an age equivalent.

Standardization of this test employed 1,039 children from Illinois. Fifty-seven percent of the group were selected from suburban schools, 26% were urban and 17% were from rural areas. All groups were identified by school officials as average. Test-retest reliability over a two week period obtained from a portion of the standardization population consisting of 171 children from rural schools was .83 for boys and .87 for girls. A correlation of .89 between scores on the VMI and chronological age is the only validity evidence reported in the manual, but it verifies the developmental sequence of the items.

The Sound Blending subtest of the Gates MacGinitie Reading Readiness Test (Gates & MacGinitie, 1972) assessed the ability to synthesize auditory parts into a meaningful unit, a complex aspect of auditory discrimination. The task required the child to chose a picture that illustrated a word presented orally in phonic parts by the examiner. Scores were recorded as stanines.

Validity was established by correlating the test results obtained from administering the measure to 173 pupils entering first grade in New York City with reading test results obtained from these pupils during the last 10 days of the school term. The Gates Primary Reading Tests - Word Recognition and Sentence Reading - were employed. The correlation coefficient thus obtained was .706. The split half reliability coefficient was .81.

The Blishen Socio-Economic Index for Occupations in Canada (Blishen & Roberts, 1976) provided a scale of six socio-economic classes determined from the occupations of the male labour force in the 1971 Canadian census. Socio-economic level for this index was based on a combination of income, education, and prestige. Approximate distribution of the Alberta population on this scale is as follows:

Level 1 (highest SES) - 3%
Level 2 - 10%
Level 3 - 10%
Level 4 - 15%
Level 5 - 22%
Level 6 - 44%

(Statistics Canada, 1976)

In summary, test variables included:

I Intelligence

1. Stanford Binet Intelligence Scale

II Attention Deficit Behavior

2. Davids Rating Scale of Hyperkinesis

III Linguistic Processes

Semantic Processing

3. Peabody Picture Vocabulary Test, PPVT
4. Metropolitan School Language and Listening
5. Metropolitan Quantitative Language

Syntax

6. Detroit Auditory Attention for Related Syllables - Syntax

Phonology

7. Wepman Auditory Discrimination Test
8. Metropolitan Rhyming
9. Gates-MacGinitie Sound Blending

IV Visual and Visual-Motor Processes

Visual Processes

10. Metropolitan Letter Recognition
11. Metropolitan Visual Matching
12. Detroit Pictorial Absurdities

Visual-Motor Processes

13. Beery Developmental Test of Visual-Motor Integration, VMI
14. Goodenough Harris Draw-a-Man Test

V Memory

15. Metropolitan Auditory Memory

6. (see above) Detroit Auditory Attention Span for Related Syllables

VI Socio-Economic Status

16. Blishen Socio-Economic Index

Procedures for Data Collection

Each measure in the test battery, excluding the Davids and the Blishen, was individually administered to all children selected for the study. Parents of the follow-up group and teachers of the comparison group, after consultation with the examiner, completed the Davids Scale. Duration of testing was approximately 2 1/2 hours, with a 15 minute juice break and rest period approximately half-way through the administration.

Subjects from the VLBW group were assessed in the clinic setting at the Glenrose School-Hospital as part of the regular 5 1/2 year follow-up visit to the ongoing research clinic. Parents accompanied the children and were encouraged to observe the assessment through the observation window. Records obtained from these families at earlier visits to the clinic provided information regarding the child's birthweight and gestational age as well as the occupations of the fathers. Data collection from this group was begun November, 1979 and was completed by May, 1984. The majority of the testing was completed by the author.

Comparison group children were assessed individually in their respective schools during the spring of 1984. Permission was obtained from the parents of these children, to complete the assessments and to obtain information from the cumulative records in the schools regarding the child's birthweight and the father's occupation. Testing was completed by the author and three research assistants trained by the author.

Statistical Method

1. Correlations among the 15 variables were calculated to determine relationships among the dependent measures.

2. A factor analysis was computed on test results of the VLBW and FBW groups to investigate the presence of cluster skills.

3. Hotelling's T^2 procedure was employed to compare scores, obtained from the test battery, with the normative data for the various tests to examine differences between the means of the sample groups and the population means. The scores of the VLBW and FBW groups were then compared applying the same analysis to explore the nature of the similarities and differences existing between the two groups. Each category was further subdivided into male and female groups for a final analysis using the Hotelling's T^2 procedure.

4. A series of one-way multivariate analysis of variance procedures were employed to investigate the influence of socio-economic status, behavior, and I.Q. upon test performance of the VLBW and FBW samples. Specific effects produced by varying categories of birthweight, gestational age, and maternal age were also examined in the VLBW sample.

5. A stepwise regression was performed to determine which test variable or variables were most predictive of membership in either the full birthweight or the very low birthweight group.

Chapter IV

Results

The results of the study will be presented in several sections including a description of the sample, general results from the battery of assessments, and analyses of the data presented under each of the six research questions. The first analysis involved computation of the Pearson Product Moment Correlations among the dependent variables. The second calculation involved a Factor Analysis of the variables to investigate the existance of skill clusters.

Hotellings T^2 comparisons were calculated to test for significant differences between the sample test means and the norms for each group, between the sample test means of the two groups, and between males and females. MANOVA's were computed to test for effects of Gestastational Age, Birthweight, and Mother's Age upon the test results of the VLBW sample, and the effects of Socio-Economic Status, IQ, and Behavior upon the test results of the FBW and VLBW samples. In the final analysis a stepwise regression procedure was used to determine which variable or variables best characterized the test performance of the VLBW sample.

For each analysis in this chapter the levels of significance have been set at less than or equal to .01, when variables were viewed separately, and at .05 when all variables were grouped together. In keeping with an exploratory study, those relationships which do not reach statistical significance, but suggest trends, will also be considered.

Description of the Sample

The VLBW sample consisted of 110 subjects, 49 of whom were female and 61 male. Information regarding chronological age, birthweight, gestational age, mother's age, and Blishen Socio-Economic Index is presented in Table 7.

The FBW sample was made up of 197 subjects, 104 females and 93 males. Chronological age, birthweight, and Blishen Socio-Economic Index are presented in Table 8.

General Results from the Battery of Assessments

Correlations

Test scores from the 15 independent variables were correlated using Pearson Product Moment Correlations (DERS PROGRAM DEST05 Descriptive Statistics), with separate calculations for each of the two groups of subjects, to determine the relationships among the skills assessed. The resulting 15x15 matrices included the Stanford Binet IQ, Peabody Picture Vocabulary Test (PPVT), School Language and Listening, Auditory Memory, Quantitative Language, Letter Recognition, Visual Matching, Beery Developmental Test of Visual Motor Integration (VMI), Rhyming, Detroit Auditory Attention Span for Related Syllables, Wepman Test of Auditory Discrimination, Gates-MacGinitie Test of Sound Blending, Draw-a-Person, David's Rating Scale of Hyperkinesis, and the Detroit Pictorial Absurdities. Correlation coefficients are reported in Tables 9 and 10.

As the ordering of the variables is arbitrary, they have been presented according to the strength of the correlation, with higher correlations grouped together. Although no correlations were of

Table 7

Characteristics of VLBW Sample

	Mean	SD	Range
Chronological Age (months)	66.8	3.5	56-81
Birthweight (grams)	1263.3	172.0	851-1500
Gestational age (weeks)	30.2	1.7	25-33
Mother's Age (years)	25.2	5.8	15-42
Socio Economic Index (1-6)*	4.8	1.2	2-6
(*1 is the highest level)			

Table 8

Characteristics of FBW Sample

	Mean	SD	Range
Chronological Age (months)	67.0	3.8	60-80
Birthweight (grams)	3342.3	474.9	2580-4569
Socio Economic Index (1-6)*	4.4	1.4	1-6
(*1 is the highest level)			

especially high magnitude, significant correlations ($p<.01$) were found between 23 pairs of variables, with moderate degrees of correlation found among many others. Sixty-eight out of 105 correlations in tests of the VLBW sample were .30 and higher, 43 were .40 and higher. With the FBW sample, 55 out of the 105 correlations were .30 and higher, while 29 were .40 and higher. Correlations of .46 and higher were significant at the .01 level are underlined in the tables. The negative correlations with the David's Behavior Scale are not surprising as a higher score on this scale indicates a greater degree of problem behavior.

Patterns were similar for the VLBW and the FBW samples. Moderately high correlations were found between the Stanford Binet IQ and all other measures. Moderate correlations were also found between the PPVT and the test of Pictorial Absurdities as well as the Metropolitan Readiness subtests which all correlate to a moderately high degree among themselves. The Wepman Test of Auditory Discrimination and the Draw-a-Person showed similar degrees of correlation with the Metropolitan subtests. The Beery Developmental Test of Visual Motor Integration correlated significantly with other measures of visual perception and visual-motor skill including Letter Recognition, Visual Matching, and the Draw-a-Person Test. The Detroit Auditory Attention Span for Related Syllables was not correlated highly with any measures other than IQ in the VLBW sample, however, in the FBW group it correlated to a moderately high degree with IQ, PPVT, the Metropolitan

Table 9

Correlations VLBW

15 dependent variables

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
a Stanford Binet IQ		.59	.56	.54	.52	.53	.51	.44	.47	.49	.41	.38	.38	.43	-.28
b PPVT S.S.			.50	.37	.43	.42	.40	.33	.22	.42	.21	.23	.28	.28	-.15
c School Language (Met)				.58	.63	.54	.60	.35	.29	.45	.40	.35	.22	.32	-.16
d Auditory Memory (Met)					.51	.48	.65	.54	.33	.39	.44	.41	.43	.31	-.17
e Quantitative Language (Met)						.57	.62	.43	.37	.15	.42	.30	.40	.22	-.35
f Letter Recognition (Met)							.61	.42	.41	.21	.40	.35	.35	.27	-.16
g Visual Matching (Met)								.47	.49	.31	.42	.41	.47	.20	-.22
h Rhyming (Met)									.30	.33	.39	.31	.38	.21	-.18
i VMI										.24	.33	.22	.39	.27	-.16
j Pictorial Absurdities											.27	.32	.30	.26	-.26
k Wepman Auditory Discrimination												.22	.22	.11	-.34
l Blending													.23	.05	-.15
m Draw-a-man														.21	-.10
n Auditory Attention Span															-.03
o David's Behavior															

(Met - indicates that these subtests are derived from the Metropolitan Readiness Tests.)

$r \geq .463,\ p \leq .01$

$r \geq .361,\ p \leq .05$

Table 10

Correlations FBW

15 dependent variables

N=197

		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
a	Stanford Binet IQ		.51	.51	.41	.47	.36	.43	.53	.33	.41	.31	.44	.30	.65	-.40
b	PPVT S.S. (Met)			.42	.28	.33	.33	.22	.46	.04	.19	.29	.42	.07	.51	-.15
c	School Language (Met)				.35	.40	.39	.38	.44	.16	.18	.30	.41	.20	.46	-.32
d	Auditory Memory (Met)					.48	.39	.45	.40	.27	.14	.11	.29	.17	.39	-.32
e	Quantiative Language (Met)						.44	.51	.41	.16	.16	.17	.33	.17	.40	-.24
f	Letter Recognition (Met)							.50	.35	.24	.17	.23	.35	.31	.25	-.25
g	Visual Matching (Met)								.36	.32	.23	.22	.35	.32	.21	-.37
h	Rhyming (Met)									.11	.16	.28	.45	.07	.45	-.17
i	VMI										.25	.05	.10	.35	.13	-.29
j	Pictorial Absurdities											.05	.21	.24	.15	-.22
k	Wepman Auditory Discrimination												.27	.19	.33	-.11
l	Blending													.20	.40	-.16
m	Draw-a-man														.08	-.28
n	Auditory Attention Span															-.30
o	David's Behavior															

(Met - indicates that these subtests are derived from the Metropolitan Readiness Tests.)

$r \geq .463$, $p \leq .01$

$r \geq .361$, $p \leq .05$

Subtests and Sound Blending. The David's Behavior Rating Scale showed low correlations with all other measures.

Factor Analysis

To determine possible clustering of variables into factors, a factor analysis (principal components with varimax rotation) was applied to all independent variables, excluding the Stanford Binet IQ as it correlated with all variables (DERS PROGRAM FACT20 Factor Analysis Package). The resulting factor loading matrices are presented in tables 11 and 12.

In order to select appropriate factor solutions for the factor analysis, the following criteria were applied--the number of factors selected was determined by the most meaningful factor solution and a factor loading of .400 or above was considered to be significant.

In the FBW sample, three factors emerged. The factor loadings are reported in Table 11. There was overlap with three variables loading on more than one factor. The first factor, including eight of the 14 variables and accounting for 25.5% of the total variance, related most strongly to auditory and language processes. The second factor, with seven of 14 variables, described visual and visual-motor processes (17.3% of the total variance), while the third factor was most strongly associated with behavior and possibly attention to detail, both auditory and visual (9.5% of the total variance). Measures of memory appeared in factors I and II.

In the VLBW sample, the factor structure was similar, but less clearly defined. The factor loadings are reported in Table 12. There

Table 11

Factor Analysis of Variables Excluding IQ

FBW Sample

Variables	h^2	I	II	III
PPVT	.560	.746	.005	.053
VMI	.564	.065	.747	-.042
David's Behavior Scale	.543	.007	-.128	-.725
Wepman Auditory Discrimination	.579	.492	-.152	.560
Rhyming	.577	.737	.169	-.069
Sound Blending	.458	.634	.182	.148
School Language & Listening	.502	.643	.255	.151
Letter Recognition	.488	.427	.515	.200
Visual Matching	.585	.362	.662	.128
Pictorial Absurdities	.225	.109	.437	.149
Quantitative Language	.519	.555	.456	-.057
Auditory Attention Span	.554	.740	.063	.047
Draw-a-Man	.618	-.028	.552	.560
Auditory Memory	.551	.481	.530	-.198

% Common Variance	48.8	33.0	18.2
% Total Variance	25.5	17.3	9.5

Table 12

Factor Analysis of Variables Excluding IQ

VLBW Sample

Variables	h^2	I	II	III
PPVT	.538	.719	.133	.050
VMI	.611	.064	.777	.062
David's Behavior Scale	.617	-.105	-.022	-.778
Wepman Auditory Discrimination	.480	.262	.365	.527
Rhyming	.456	.461	.455	.191
Sound Blending	.278	.338	.265	.307
School Language & Listening	.715	.769	.260	.238
Letter Recognition	.556	.466	.551	.187
Visual Matching	.700	.434	.656	.285
Pictorial Absurdities	.543	.699	.089	.214
Quantitative Language	.607	.445	.498	.401
Auditory Attention Span	.540	.557	.237	.417
Draw-a-Man	.573	.146	.741	.043
Auditory Memory	.616	.590	.482	.188
% Common Variance		42.0	37.4	20.6
% Total Variance		23.5	20.9	11.5

was a greater degree of overlap between the first two factors with five variables loading on both of these factors. Although more loosely described than in the FBW sample, factor I is most closely associated with auditory and language processes, containing 9 of the 14 variables and accounting for 23.5% of the total variance. The second factor includes seven of the 14 variables and appears to focus upon visual and visual-motor processes (20.9% of the total variance). Factor III is primarily behavior and attention to auditory detail. The factor structure of these two groups reflects current theories of academic skill development which describe profiles of strengths and weaknesses related to differentiation of the auditory/language and visual/motor skills. As this structure was not, however, clearly defined, all variables were treated separately in subsequent analyses.

Research Questions

Question 1: Is there evidence of decreased functioning among a sample of VLBW children (who were appropriate for gestational age at birth and free from major handicaps at age 5 1/2 years) on a battery of subtests designed to measure learning processes presumed to be related to learning disabilities?

Question 2: Does the mean test performance of the VLBW sample differ from the mean test performance of a comparable full birthweight (FBW) sample on these measures?

A Hotelling T^2 statistical procedure was employed to address the major questions of this study. The DERS PROGRAM MULV08 Two Sample Hotelling T^2 procedure provided an overall test for difference between sample and norm means, as well as tests of differences for each variable. Results of the Hotelling T^2 comparing variable means of the VLBW group with means for the norming sample are reported in Table 13. The Hotelling T^2 for the FBW group is presented in Table 14, while results of the Hotelling T^2 comparing the variable means for the VLBW group with means for the FBW group are presented in Table 15. Overall effects were also calculated for these comparisons.

In answer to question 1, there was evidence of decreased functioning in the VLBW sample. As indicated by the probability values, there was a significant overall difference between the variable means of the VLBW group and the test means, viewing the variables collectively. Significant differences also occurred in comparisons of seven of the 15 variables. In all seven, including the VMI, the David's Behavior Scale, Rhyming, School Language and Listening, Visual Matching, Pictorial Absurdities, and the Draw-a-Man, the direction of the difference indicated decreased functioning in the VLBW group. These subtests did not draw upon skills from one particular information processing area, but rather measured abilities from the three general areas of language processes, visual processes, and behavior.

On three of the 15 variables, the Stanford Binet I.Q., the PPVT, and the Wepman Test of Auditory Discrimination, the VLBW mean was higher than the test norm, but not significantly higher. Research (Lynn, Hampson, & Mullineux, 1987) suggests that the trend has been toward a mild increase in mean IQ scores since the Stanford Binet was normed in 1972. The PPVT has been renormed since the present form of the test was

Table 13

Hotelling's T^2

VLBW vs Test Norms

Variable	VLBW$\overline{X}$	VLBW SD	Norm$\overline{X}$	T^2	F	df1	df2	P
Stanford Binet IQ	104.96	14.8	100	12.21	.658	15	95	.827
PPVT	102.76	15.8	100	3.33	.180	15	95	.999
VMI	94.44	9.1	100	40.41	2.178	15	95	.011
David's Behavior Scale*	20.42	4.0	18	38.79	2.090	15	95	.015
Wepman Auditory Discrimination	3.17	1.2	3	2.39	.129	15	95	1.000
Rhyming	7.36	3.9	10	49.80	2.684	15	95	.001
Sound Blending	5.00	1.8	5	0.00	0.000	15	95	1.000
School Language & Listening	10.08	2.5	12	66.22	3.570	15	95	.000
Letter Recognition	8.96	2.8	9	.02	.000	15	95	1.000
Visual Matching	9.03	3.0	12	106.93	5.763	15	95	.000
Picture Absurdities	93.50	10.1	100	39.40	2.082	15	95	.010
Quantitative Language	7.21	2.2	8	14.31	.771	15	95	.713
Auditory Attention Span	96.77	29.8	100	1.28	.069	15	95	1.000
Draw-a-Man	89.82	13.3	100	63.53	3.424	15	95	.000
Auditory Memory	8.15	2.6	9	11.81	.636	15	95	.846
Overall				537.64	28.98			.000

* a higher score indicates a greater degree of problem behavior

Table 14

Hotelling's T^2

FBW vs Test Norms

Variable	FBW$\overline{X}$	FBW SD	Norm$\overline{X}$	T^2	F	df1	df2	P
Stanford Binet	107.55	14.1	100	56.63	3.271	15	182	.000
PPVT	107.35	16.3	100	39.94	2.317	15	182	.004
VMI	97.01	8.2	100	25.82	1.598	15	182	.078
David's Behavior Scales *	17.29	5.8	18	2.82	.162	15	182	.999
Wepman Auditory Discrimination	3.7	1.0	3	81.20	4.698	15	182	.000
Rhyming	8.58	3.5	10	31.77	1.967	15	182	.023
Sound Blending	5.84	1.8	5	44.79	2.589	15	182	.001
School Language & Listening	10.60	2.2	12	80.35	4.648	15	182	.000
Letter Recognition	9.54	2.3	9	10.61	.614	15	182	.871
Visual Matching	9.72	2.9	12	125.24	7.232	15	182	.000
Picture Absurdities	97.22	9.8	100	15.63	.902	15	182	.568
Quantitative Language	7.70	1.8	8	5.29	.305	15	182	.996
Auditory Attention Span	96.40	18.4	100	7.53	.435	15	182	.972
Draw-a-Man	96.66	13.5	100	12.02	.693	15	182	.798
Auditory Memory	8.68	2.3	9	3.88	.224	15	182	.999
Overall				1178.86	68.04			.000

* a higher score indicates a greater degree of problem behavior

Table 15

Hotelling's T^2

VLBW vs FBW

Variable	VLBW N = 110	FBW N = 197	T^2	F	df1	df2	P
Stanford Binet IQ	104.96	107.55	2.29	.136	15	291	1.000
PPVT	102.76	107.36	5.69	.338	15	291	.993
VMI	94.44	97.02	6.36	.378	15	291	.987
David's Behavior Scale*	20.42	17.29	24.538	1.561	15	291	.084
Wepman Auditory Discrimination	3.17	3.70	15.66	.930	15	291	.535
Rhyming	7.36	8.58	7.80	.463	15	291	.962
Sound Blending	5.0	5.84	15.70	.933	15	291	.532
School Language & Listening	10.08	10.60	3.58	.213	15	291	.999
Letter Recognition	8.96	9.54	3.67	.218	15	291	.999
Visual Matching	9.03	9.72	3.99	.237	15	291	.999
Picture Absurdities	93.5	97.22	9.65	.232	15	291	.863
Quantitative Language	7.21	7.70	4.41	.262	15	291	.998
Auditory Attention Span	96.77	96.40	0.02	.001	15	291	1.000
Draw-a-Man	89.82	96.66	18.24	1.084	15	291	.370
Auditory Memory	8.15	8.68	3.37	.200	15	291	1.000
Overall			98.68	5.86			.000

* a higher score indicates a greater degree of problem behavior

published in 1965. The mild increase in mean was recognized in the renorming procedure (Dunn, L.M. & Dunn, L.M., 1981). Differences on the Wepman Test of Auditory Discrimination are minimal.

The importance of including a comparison group with a similar regional make-up to the target group of the study becomes apparent when an examination is made of the results of the Hotelling T^2 test with the FBW sample. When comparisons were made between means of the FBW group and the norms of the tests, findings were similar to comparisons made with the VLBW group. The overall difference, viewing the 15 variables collectively, was significant. Significant differences also occurred with seven of the 15 variables, although decreased functioning was found with only three of these, including Rhyming, School Language and Listening, and Visual Matching. The test performance on the VMI approached significance (P=.07) as well. These four measures had also been significantly lower than the norms in the VLBW sample.

Increased ability was found on the remaining four significant variables in the test performance of FBW subjects--on the Stanford Binet, the PPVT, the Wepman Test of Auditory Discrimination, and Sound Blending. Means for the first three of these variables were also higher than the norm in the VLBW sample, but not significantly so.

It must be emphasized that for all variables where a significant difference from the norm mean occurred, the direction of the difference was the same for both samples, but, for several measures, significance was reached in the test performance of only one sample.

In light of these findings, caution must be exercised in generalizing the results. Deviations from the norm were consistent between the two samples suggesting that variations in the test profiles of sample subjects may be due, in part, to variations in the construct validity of the tests employed and to the fact that the test instruments have been drawn from a number of sources using different norming populations and procedures. Differences from the norms may also be the product of experiences or environmental influences common to both samples. Testing procedures may have influenced the test results of the two samples in a similar way as well.

When the VLBW and FBW groups were compared, to answer question 2, no significant differences were found on the individual measures (see Table 15), although the results of the David's Behavior Scale approached significance ($p=.08$). The overall difference between groups was, however, significantly different. Deviations from the norm means were generally in the same direction and of a similar magnitude for each group. The overall trend was, however, for weaker scores among the VLBW sample. This was found on 14 of the 15 variables, although the differences were not great.

Question 3: Is test performance of VLBW males different from test performance of VLBW females on the set of variables employed in this study?

The two sample Hotelling T^2 procedure was performed to address the third research question of this study relating to male-female differences in the VLBW sample. The results of this analysis are reported in Table 16. No significant differences were found among individual variables, nor was there a significant difference when variables were grouped together. On 12 of the 15 measures scores were weaker for males than for females but differences were often extremely small. Similar results were found with the FBW sample (see Table 17). No significant difference was found on individual variables. Females scored higher than males on seven of 15 subtests in this group, but not significantly higher. An overall significant difference was found, however, when measures were viewed collectively.

It appears that any constitutional weakness, increasing vulnerability to difficulties with preschool skills among males, may have been eliminated by the process of removing all subjects with handicapping conditions. The remaining group of subjects is comprised of a larger number of females than males (61 females, 49 males). This resulting sample of healthy males and females performed in a very similar manner on preschool ability tests.

Question 4: Is test performance of the VLBW sample influenced by gestational age, birthweight, or mother's age?

A series of one-way multivariate analyses of variance was performed to investigate the specific effects of the varying categories of birthweight, gestational age, and mother's age upon the test performance of the VLBW group. The DERS One Way Multivariate Analysis of Variance (MANOVA) Program (MULV16) was employed. The Helmert contrast Matrices were constructed to test for group differences.

Table 16

Hotelling's T^2 VLBW Male vs Female

Variable	Male $\overline{X}$ N=49	Female $\overline{X}$ N=61	T^2	F	df1	df2	P
Stanford Binet IQ	103.00	106.54	1.54	.083	15	94	1.00
PPVT	103.39	102.26	.135	.007	15	94	1.00
VMI	94.25	94.60	.038	.002	15	94	1.00
David's Behavior Scale*	21.02	19.93	1.951	.105	15	94	1.00
Wepman Auditory Discrimination	2.88	3.41	5.855	.315	15	94	.994
Rhyming	6.74	7.87	2.304	.124	15	94	1.00
Sound Blending	4.76	5.18	1.345	.072	15	94	1.00
School Language & Listening	9.88	10.25	.601	.032	15	94	1.00
Letter Recognition	8.90	9.02	.047	.003	15	94	1.00
Visual Matching	9.02	9.03	.000	.000	15	94	1.00
Picture Absurdities	110.16	94.93	.863	.046	15	94	1.00
Quantitative Language	7.06	7.33	.400	.022	15	94	1.00
Auditory Attention Span	95.80	97.56	.093	.005	15	94	1.00
Draw-a-Man	90.80	89.03	.468	.025	15	94	1.00
Auditory Memory	8.16	8.13	.004	.000	15	94	1.00
Overall			19.40	1.04			.419

* a higher score indicates a greater degree of problem behavior

Table 17

Hotelling's T^2 FBW Male vs Female

Variable	Male X N=93	Female X N=104	T^2	F	df1	df2	P
Stanford Binet IQ	106.58	108.42	.839	.048	15	181	1.00
PPVT	108.69	106.16	1.174	.068	15	181	1.00
VMI	98.05	96.07	2.820	.163	15	181	1.00
David's Behavior Scale*	18.18	16.51	4.066	.235	15	181	.999
Wepman Auditory Discrimination	3.66	3.74	.293	.017	15	181	1.00
Rhyming	8.74	8.44	.353	.020	15	181	1.00
Sound Blending	5.98	5.72	1.041	.060	15	181	1.00
School Language & Listening	10.66	10.55	.118	.007	15	181	1.00
Letter Recognition	9.26	9.79	2.592	.150	15	181	1.00
Visual Matching	9.76	9.68	.039	.002	15	181	1.00
Picture Absurdities	96.09	98.24	2.360	.136	15	181	1.00
Quantitative Language	7.82	7.60	.717	.041	15	181	1.00
Auditory Attention Span	95.23	97.45	.717	.041	15	181	1.00
Draw-a-Man	96.63	96.69	.001	.000	15	181	1.00
Auditory Memory	8.75	8.61	.197	.011	15	181	1.00
Overall			33.69	1.94			.190

* a higher score indicates a greater degree of problem behavior

Information on the distribution of subjects is presented in Table 18 for gestational age, Table 19 for birthweight and Table 20 for mother's age.

The largest number of subjects fell within the 30-31 week gestational age category (44.5%) which is in keeping with the largest birthweight category of 1251-1500 grams (59%). This is the expected weight at 30 1/2 to 31 1/2 weeks gestation (Lubchenco, 1966). The smallest infant in the sample was 851 grams at birth. The earliest gestational age was 25 weeks. Test results from these two subjects have been included in Appendix B. Both were average and above average in test performance.

The majority of mothers were in the 26-30 year age range (32%) with a large number of mothers in the 21-25 year range (25.5%) and a larger than expected number of mothers in the 15-20 year age range (25.5%) when compared with provincial statistics for all births in Alberta in 1976 the midyear of the study (^{2}=86.03, df=4-1, $p<.001$). The youngest was 15 years old. Seventeen percent of mothers were above 30 years of age; the oldest being 42.

Results of the MANOVA's comparing VLBW subjects from varying categories of gestational age, birthweight, and mother's age are presented in Table 21. The multivariate analyses of variance found that the main effects for gestational age (within the range of 25 to 33 weeks) and birthweight (within the range of 851 to 1500 grams) upon the test results were non-significant. The overall effect of mother's age was also non-significant. Parenthetically, there was a significant

Table 18

Distribution of VLBW Subjects According to Gestational Age

	Weeks Gestation	N	% of VLBW Sample
Group 1	25-27	6	5.5%
Group 2	28-29	27	24.5%
Group 3	30-31	49	44.5%
Group 4	32-33	28	25.5%
	$\bar{X}$ = 30.23	110	100%

Table 19

Distribution of VLBW Subjects According to Birthweight

	Weight in Grams	N	% of VLBW Sample
Group 1	<1000	12	11
Group 2	1001-1250	33	30%
Group 3	1251-1500	65	59%
	$\bar{X}$ = 1263.24	110	100%

Table 20

Distribution of VLBW Subjects According to Mother's Age

	Age in Years	N	% of VLBW Sample	% in Alberta 1976
Group 1	15-20	28	25.5%	17.9%
Group 2	21-25	28	25.5%	38.0%
Group 3	26-30	35	32 %	31.0%
Group 4	31-35	14	13 %	9.9%
Group 5	>35	5	4 %	3.1%
	$\bar{X}$ = 25.2	110	100 %	99.9 %

* .1% of 1976 Alberta population were <15 years of age.

difference (P<.05) between the results of the group with the youngest mothers (age 15-20 years) compared with the results of the remainder of the group. These results are reported in Table 22. The test performance for children born to the youngest mothers was significantly lower than the test performance of the others grouped together. Group means are reported in Appendix C.

Question 5: Is test performance of the VLBW and FBW samples influenced by socio-economic status, behavior or IQ as measured in this study?

To answer this question it was necessary to analyze the data in two ways. It was necessary to establish differences in distribution according to socio-economic status, behavior and IQ as well as to determine the impact upon test performance of these variables.

Data representing the distribution of VLBW and FBW subjects into categories of Socio-Economic Status (SES), IQ, and Behavior are reported in Tables 23, 24 and 25 respectively. The VLBW sample was significantly disadvantaged when compared with the FBW sample on the category of SES (^{2} = 18.27, df=4, p<.01). The majority of VLBW subjects came from families in the lowest category of SES (category 6) while the largest number of FBW families were from the category one level higher (category 5). Compared with statistics for the Canadian population, these groups are within the range expected in 1976, however, the lowest category is very large and does not differentiate groups of blue collar workers (See Canadian norms from Robertson, 1976). For the VLBW sample this data was collected at the first neonatal clinic visit when 25.5% of the mothers were less than 20 years of age. It is possible that many of the fathers would, therefore, be poorly established professionally. For the FBW sample the data was collected at age 5 1/2 years at kindergarten registration. Information was not available on 35 FBW families, which may also be misleading as many fathers were either absent from the home or did not report information on occupation suggesting unemployed status or uncertain guardianship status. Another important point is the fact that 100% of the FBW group was urban, while 19% of the VLBW group was rural. All farming and fishing occupations are included in Blishen category 6.

The distribution of subjects, according to IQ, was similar for the VLBW and FBW samples. The greatest number of subjects in each sample fell in the 101-115 IQ range, with 90.5% of the FBW group and 90% of the VLBW group in the 86-130 IQ range. There was a slight difference at the extreme ends with a greater number of VLBW subjects at the lower end of the continuum in the 70-85 IQ category (3.5% FBW and 8% VBLW). At the upper end of the range, 6% of the FBW group were in the 131-145 category while only 2% of the VLBW group attained this level. This difference was not significant (^{2} = 6.20, df=4, $p<.25$).

In the Behavior groupings, considerable differences were found between the VLBW and FBW distributions. Eight percent of the FBW sample was classified as hyperactive, while 17% of the VLBW group were so labelled. Conversely, 77% of the FBW sample were grouped in the normal category, while only 33% of the VLBW sample were found to be free from

Table 21

Main Effects of Gestational Age, Birthweight and Mother's Age on Test Results of VLBW Sample

	DF_1	DF_2	F-Ratio	Probability
Gestational Age	45	274.1	1.125	.281
Birthweight	30	186	.917	.595
Mother's Age	60	357.4	1.156	.214

Table 22

Group Effects of Mother's Age on Test Results of VLBW Sample

Group 1 - age 15-20 years
Group 2 - age 21-25 years
Group 3 - age 26-30 years
Group 4 - age 31-35 years
Group 5 - age > 35 years

Mother's Age Group	DF_1	DF_2	F-Ratio	Probability
Overall	60	357.4	1.156	.214
Group 1 - 2345	15	91	1.835	.041
Group 2 - 345	15	91	.943	.521
Group 3 - 45	15	91	1.098	.369
Group 4 - 5	15	91	.952	.511

Table 23

Distribution of VLBW and FBW Sample on SES

SES Group	Blishen Category	VLBW N	% VLBW Sample	FBW N	% FBW Sample
Group 1	1+2	4	3.6	23	14.2
Group 2	3	14	12.7	13	8.0
Group 3	4	25	22.7	36	22.2
Group 4	5	24	21.8	54	33.3
Group 5	6	43	39.0	36	22.2
		110	100%	*162	100%

(* Information was available on only 162 of the 197 FBW students.)

Category 1 indicates highest level of SES.

Table 24

Distribution of VLBW and FBW Samples on IQ

IQ Group	IQ	VLBW N	% VLBW Sample	FBW N	% FBW Sample
Group 1	70-85	9	8%	7	3.5%
Group 2	86-100	30	27%	60	30.5%
Group 3	101-115	44	40%	72	36.5%
Group 4	116-130	25	23%	46	23.5%
Group 5	131-145	2	2%	12	6.0%
		110	100%	197	100%

VLBW IQ $\overline{X} = 104.96$ FBW IQ $\overline{X} = 107.55$

Table 25

Distribution of VLBW and FBW Samples on Behavior

Behavior Group	Behavior	VLBW N	% VLBW Sample	FBW N	% FBW Sample
Group 1	Hyperactive	19	17%	16	8%
Group 2	Suspicious	55	50%	30	15%
Group 3	Normal	36	33%	151	77%
		110	100%	197	100%

suspicion of hyperactivity. This difference was highly significant (^{2} = 58.36, df=2, p<.001).

The MANOVA's comparing the test results of varying SES, IQ, and Behavior categories among the VLBW and FBW samples are presented in Tables 26, 27, 28, 29, 30, and 31. Significant effects were produced by each of these variables upon the test results of the two sample groups. In the VLBW sample, the effect of SES approached significance in the overall picture (P=.07), with a significant effect occurring in the comparison of Blishen level 4 with the lowest levels, 5 and 6, (P=.03) which contained the majority of the VLBW subjects (Table 26). The comparison between levels 5 and 6 approached significance (P=.07). The trend was very definitely towards decreased functioning with decreased SES. The group means are presented in Appendix D. In the FBW sample, an overall effect was seen in comparing the test results of varying categories of SES (Table 27). A comparison of Blishen category 3 with the remainder of the sample approached significance (P=.07), while a comparison of Blishen categories 5 and 6 was significant (P=.03). The tendency in this sample was also toward poorer test performance with lower SES (See Appendix E).

The effects of IQ were highly significant both overall and when groupings were viewed separately (Tables 28 and 29). In the VLBW sample, significant differences were seen in comparisons of the two IQ categories below 100 with higher IQ groups, however, the 3 categories of IQ above 100 did not perform significantly differently on the tests. In the FBW sample, effects of IQ were significant among all categories with the exception of the highest IQ range (131-145) which approached significance (P=.06). Not surprisingly, as IQ increased, test performance also increased. Group means are presented in Appendices F and G.

Behavior also proved to be a significant variable (Tables 30 and 31). In the VLBW sample, significant differences were found among the three groups (hyperactive, suspicious, and normal) as well as in the main effect. In the FBW sample, a significant main effect was produced by behavior. A significant difference also occurred between the hyperactive group and the remaining sample but not between the suspicious and the normal group. Obvious improvement in test performance was seen in the movement from hyperactive to normal behavior. Test means are presented in Appendices H and I.

Question 6: Which variable or variables best characterize the VLBW group?

Finally, a stepwise regression (DERS PROGRAM MULR10) was calculated to determine which variable or set of variables best differentiates the VLBW sample from the FBW sample. The dependent variable was group membership, thus this analysis was equivalent to a 2-group discriminant function analysis. Results of this analysis are reported in Table 32. Six variables were found to be significant predictors of group membership, the strongest one being David's behavior, followed by Auditory Blending, the Draw-a-Man test, the Wepman test of Auditory Discrimination, the Stanford Binet IQ, and Pictorial Absurdities. The VLBW and FBW groups could not, however, be well discriminated on the

Table 26

Effects of Socio-economic Status on Test Results VLBW Sample

MANOVA (Helmert Contrast)

Group 1 - Blishen Category 1&2 (highest SES)
Group 2 - Blishen Category 3
Group 3 - Blishen Category 4
Group 4 - Blishen Category 5
Group 5 - Blishen Category 6 (lowest SES)

Group	DF_1	DF_2	F-Ratio	Probability
Main Effect	60	357.4	1.31	.073
Group 1 vs. 2345	15	91	1.31	.212
Group 2 vs. 345	15	91	.54	.907
Group 3 vs. 45	15	91	1.89	.033
Group 4 vs. 5	15	91	1.65	.077

Table 27

Effects of Socio-economic Status on Test Results FBW Sample

MANOVA (Helmert Contrast)

Group	DF_1	DF_2	F-Ratio	Probability
Main Effect	60	560.4	1.51	.010
Group 1 vs. 2345	15	143	1.32	.198
Group 2 vs. 345	15	143	1.65	.068
Group 3 vs. 45	15	143	1.52	.106
Group 4 vs. 5	15	143	1.83	.036

basis of these variables because the size of the multiple correlation was very low (R = .392). The amount of predictability increased by only .12 (from .273 to .392) when all six significant variables were included. For this reason, the success rate of assigning subjects to one group or the other on the basis of either the most significant variable, or all six significant variables, was very low. This suggests that there exists a great deal of overlap between the two samples on test performance.

Summary

From these analyses there emerges a picture of the nondisabled VLBW sample as a healthy, highly functional group of kindergarten students. Although there was evidence of significantly decreased functioning on several variables when the test performance of the VLBW group was compared with the norms of the tests, differences on these tests were minimal and were non-significant when compared with the test performance of the FBW group. On four measures, the FBW group performed significantly higher than the norm but, on three of these variables (Stanford Binet, PPVT, and Wepman Auditory Discrimination), the VLBW group was also higher than the mean, but not significantly so. In fact, for all variables the direction of the difference was the same for both samples. The comparison of the test performance of the VLBW and FBW groups did, however, produce a significant overall difference, which was, most likely, due to the general trend towards weaker scores among the VLBW sample. This trend was found on 14 of the 15 variables.

Table 28

Effects of IQ on Test Results VLBW Sample

MANOVA (Helmert Contrast)

Group 1 - IQ 70-85
Group 2 - IQ 86-100
Group 3 - IQ 101-115
Group 4 - IQ 116-130
Group 5 - IQ 131-145

Group	DF_1	DF_2	F-Ratio	Probability
Main Effect	56	360	2.59	.001
Group 1 vs. 2345	14	92	7.00	.001
Group 2 vs. 345	14	92	1.89	.037
Group 3 vs. 45	14	92	.91	.554
Group 4 vs. 5	14	92	.76	.714

Table 29

Effects of IQ on Test Results FBW Sample

MANOVA (Helmert Contrast)

Group	DF_1	DF_2	F-Ratio	Probability
Main Effect	56	562.3	4.55	.001
Group 1 vs. 2345	14	144	6.93	.001
Group 2 vs. 345	14	144	14.37	.001
Group 3 vs. 45	14	144	6.64	.001
Group 4 vs. 5	14	144	1.66	.063

Table 30

Effects of Behavior on Test Results VLBW Sample

MANOVA (Helmert Contrast)

Group 1 - hyperactive

Group 2 - suspicious

Group 3 - normal

Group	DF_1	DF_2	F-Ratio	Probability
Main Effect	60	188	1.91	.006
Group 1 vs. 23	14	94	2.01	.025
Group 2 vs. 3	14	94	2.03	.023

Table 31

Effects of Behavior on Test Results FBW Sample

MANOVA (Helmert Contrast)

Group	DF_1	DF_2	F-Ratio	Probability
Main Effect	28	292	1.62	.028
Group 1 vs. 23	14	146	2.27	.001
Group 2 vs. 3	14	146	.67	.785

Table 32

Prediction of VLBW or FBW Group Membership

Stepwise Regression

Variable	Regression Coefficient	R	F	Probability
David's Behavior	-.187	.273	24.55	.001
Blending	.159	.330	11.67	.001
Draw-a-Man	.139	.357	6.46	.001
Wepman Auditory Discrimination	.135	.370	3.43	.009
Stanford Binet IQ	.148	.382	3.17	.008
Pictorial Absurdities	.099	.392	2.64	.016

When test performance of the VLBW male subjects was compared with the test performance of the VLBW female subjects, no significant differences were found among individual variables, nor was there any significant difference when variables were viewed collectively. It appears that the elimination of handicapped subjects from the VLBW sample may also have eliminated the group of males that would have been predisposed to difficulties on preschool measures of cognitive abilities. The VLBW sample was made up of a larger number of females than males.

Examination of the distribution of subjects according to gestational age and birthweight groupings indicated that the largest number of subjects fell within the 30-31 week gestational age category (44.5%) which is appropriate gestational age for the largest birthweight category of 1251-1500 grams (59%). Effects, on test performance, of gestational age and birthweight within the limited range examined in the VLBW sample, were non-significant.

The distribution of subjects according to mother's age was found to be significantly different from the Alberta distribution in 1976, the midyear of the study. A larger than expected number of mothers fell within the 15-20 year age range, with a smaller than expected number of mothers in the 21-25 year age range, which was the largest group in the Alberta population in 1976. The overall effect of mother's age upon test performance was non-significant, however the test performance of chiliren born to the youngest mothers was significantly lower than the test performance of the other subjects grouped together.

The VLBW sample was significantly disadvantaged on the SES Scale when compared with the FBW sample, but not when compared with the Canadian population. Age of subjects at the time of data collection and rural-urban status may, however, have influenced the VLBW - FBW SES category differences. Close attention must be paid to these factors as the trend in test performance was very definitely towards decreased functioning with decreased SES.

The distribution of subjects according to IQ was similar for FBW and VLBW samples. It is not surprising that effects of IQ upon test performance were highly significant both overall and when groupings were viewed separately. As IQ increased, test performance also increased.

Considerable differences were found in distribution of VLBW and FBW subjects according to attention deficit behavior, with a significantly larger group of VLBW subjects falling into the categories of suspicious and hyperactive and a significantly larger group of FBW subjects falling into the category of normal. When effects of behavior upon test performance were examined, a significant main effect as well as significant differences between the test performance of the two samples, when the three behavior categories were compared, were seen. Obvious improvement in test performance was associated with movement from hyperactive to normal behavior categories. This effect was less obvious between the suspicious and normal categories in the FBW sample.

An analysis of the predictive efficiency of the variables in determining membership in the VLBW or FBW groups found behavior to be the strongest element with five other variables reaching significance.

The discriminating power of the most efficient variable was, however, limited. Success rate of assigning group membership did not increase greatly by including all six significant variables, suggesting a great deal of overlap in the test performance of the two samples.

Chapter V

Discussion and Conclusions

Discussion

VLBW - FBW Differences

The central concern of this study was an analysis of the learning profile of a very low birthweight (VLBW) sample compared with the learning profile of a full birthweight (FBW) sample at 5 1/2 years of age. To make this comparison, 110 VLBW subjects and 197 FBW subjects were individually assessed using a battery of ten different instruments to measure general cognitive development as well as specific aspects of auditory/language processes, visual/visual-motor processes, memory, attention deficit behavior and socio-economic status.

Although the results of past research have strongly implicated very low birthweight as a causative factor in the development of learning disabilities among an otherwise healthy population of school children, little support was found for this position in the present study. Only in regard to attention deficit behavior and socio-economic status was there strong statistical evidence that the VLBW sample was different from the FBW sample. A general trend for lower scores in the VLBW sample also produced a significant overall effect. Application of varying statistical procedures produced consistent results indicating that the two samples were much alike in many respects.

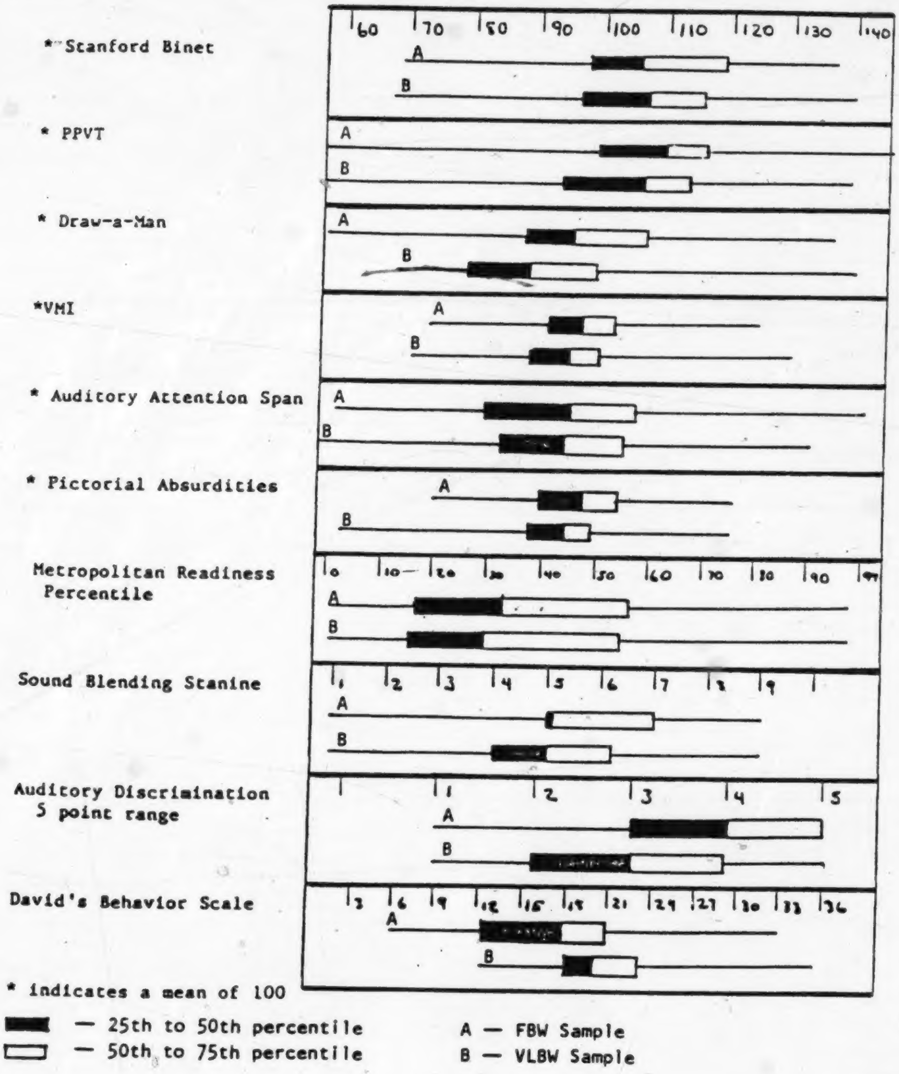
Although comparing the test results of the VLBW sample with the norms of the tests indicated significantly reduced functioning on 7 of 15 variables, differences from the norms in the same direction and of a similar degree were also found in the FBW sample. In fact, when the test results of the VLBW sample were compared with the test results of the FBW sample, no significant differences were found among the individual variables. An overall significant effect was produced, however, by the tendency for VLBW scores to fall slightly lower than the FBW scores which occurred with 14 of the 15 variables. The remaining variable mean (Auditory Attention Span) was essentially equal for the two samples.

It appears that the cognitive skills and preschool readiness skills, as measured by the present study, were very similar for the two samples. Presented graphically, in Figure 3, the total and interquartile range for the two samples, are seen to overlap greatly. In light of the failure of any single cognitive variables or group of variables to differentiate the VLBW from the FBW sample, generalizations regarding the extent of learning disabilities in the sample will be limited.

It appears that by eliminating all subjects with major handicapping conditions from the VLBW sample an essentially normal distribution of skills is produced with regard to cognitive functioning, suggesting that the proportion of learning disabled subjects among the nonhandicapped VLBW sample may be similar to the proportion of learning disabled subjects in the FBW sample. For the purpose of studying learning disabilities some information is lost by analyzing mean scores rather than studying the variability within individual learning profiles. An

Figure 3

Total and Interquartile Ranges for Each Measure



indepth investigation of profile variability may be a consideration for future research in this area.

Caution must be taken, however, in analyzing profiles resulting from a test battery drawn from a variety of sources. Recurrent patterns of variation in such profiles can, in fact, be a product of the multivariate tool, as the norms are derived from varying procedures, populations, geographical areas, and periods of time. In clinical practice, adjustments are made in interpreting results by accounting for the tendencies of various instruments to over or underestimate ability. Familiarity with the subject population and the assessment tools is necessary to make these adjustments. In the statistical analysis of results derived from varying sources, such accommodation is not possible. Use of comparison or control groups is essential, therefore, to clarify results.

Male-Female Differences

Previous studies (Drillien, 1967; Drillien, Thomas & Burgoyne, 1980; DeHirsch, Jansky & Langford, 1966; Fitzhardinge & Ramsay, 1973; Hunt, 1981; Rubin, Rosenblatt & Balow, 1973) suggest that VLBW males may be more vulnerable to difficulties in academic skill development than females. The present study does not lend support to this theory. Comparisons of the test performance of male subjects with the test performance of female subjects produced no significant differences in the VLBW sample, although the tendency was for males to score slightly lower than females. It was suggested, in the results chapter, that the elimination of all subjects with handicapping conditions may also have removed from the VLBW sample those male subjects predisposed to weaknesses on measures of preschool cognitive processes. The VLBW sample was comprised of a greater number of female subjects than males (61 females, 49 males). In previous studies of male-female differences among the VLBW population, males may have been placed at a disadvantage as the categories for study are often based upon absolute birthweight groupings rather than precentiles. As male infants are larger there is inequity in this method of grouping subjects.

Gestational Age and Birthweight Categories

Influence on test performance of gestational age and birthweight, within the limited range examined in the present study, was nonsignificant. The majority of VLBW subjects were in the 1251-1500 gram birthweight group (59%), at 30 to 31 weeks gestation (44.5%) which is appropriate growth for gestational age. Test performance of varying birthweight and gestational age groupings did not differ significantly.

Mother's Age

The overall effect of mother's age upon test performance in the VLBW group was also non-significant. There was, however, a significant difference between the test performance of the group with the youngest mothers (age 15-20 years) and the test performance of the remaining sample. A larger than expected number of mothers fell into this young age group (25.5%) compared with 17.9% of the population in that age range in Alberta in 1976, the midyear of the study. As significantly reduced test performance was observed among subjects from this category, further research examining other factors related to maternal age appears to be warranted. Socio-economic status, life style, physical maturation, and pre-natal care should be considered in such an investigation.

Socio-economic Status

Research of the very large collaborative study following 50,000 births in the U.S. from 1959 to 1965 (Broman, Nichols & Kennedy, 1975) suggested that socio-economic status was the single most important factor in determining outcome in various aspects of development including cognitive development. This was found to be true for all children, including full birthweight as well as low birthweight. There was evidence in the present study to support this research. The effects of SES upon the test performance of both VBLW and FBW samples were significant, with a trend towards decreased functioning with decreased SES. This factor becomes even more important when the distribution of subjects into SES categories is examined. The VLBW group was significantly disadvantaged when compared with the FBW group. The majority of VLBW subjects were within Blishen Category 6 (39.0%) the lowest category, while the majority of FBW subjects fell into category 5 (33.3%). More than half of each group was, however, in categories 5 and 6 (see p.97) which is in harmony with Alberta Statistics (Statistics Canada, 1976).

As previously discussed in the results chapter, the social data for the VLBW sample was collected at birth, while this information was gathered at age 5 1/2 years for the FBW sample. With a large proportion of very young mothers, it is expected that the fathers of VLBW subjects (on whom the Blishen Socio-economic Index is based) would have been less well established professionally at the time of rating than the FBW fathers. A difference in urban-rural status also exists, with 100% of the FBW sample derived from an urban population, while 19% of the VLBW subjects had rural backgrounds.

Recognition of the importance of SES with regard to outcome suggests the need for early intervention with the most disadvantaged families with VLBW infants. While early parent-child interactions cannot alter organic structures, the adaptation of the child to his or her environment is greatly influenced by the child's relationship with the mother and by the social situations and cognitive experiences to which the child is exposed. Improved functioning is most likely to occur with the optimal support more often found in families of higher SES. Counselling and support services for families of limited resources rearing VLBW children may lead to improvements in future functioning. Sensitivity towards the group of very young mothers appears to be of particular importance.

Attention Deficit Behavior

The variable of attention deficit behavior proved to be a very important factor in the comparison of VLBW and FBW subjects. Highly significant differences in the distribution of subjects occurred on this dimension, with 77% of the FBW sample categorized as normal while only 33% of the VLBW sample fell into this group. Behavior was the most efficient variable in differentiating the VLBW and FBW groups although the power to discriminate was moderate. More importantly, this variable produced significant impact upon the test performance of the subjects. Obviously stronger test performance was seen in the normal category when compared with the suspicious and 'hyperactive' groups. A limitation in generalizing this finding exists in the fact that the David's Behavior Scale was completed by a different source for each sample. Parents of the VLBW sample completed the behavior scale while teachers of the FBW sample provided the ratings. This may have influenced the general level of the behavior assessment as settings and behavioral expectations may have varied from one rating group to the other, although both groups of adults would have been very familiar with the subjects to be evaluated and ratings were completed with the guidance of an examiner.

IQ Levels

It was not surprising to discover that level of IQ produced major impact upon test performance, with stronger test scores accompanying higher IQ's. However, because the distribution of subjects according to IQ categories was similar for VLBW and FBW samples, this variable was considered to be part of the outcome rather than in intervening variable. Differences between the groups in IQ level would have necessitated accommodation of this factor in interpreting findings. The similarity in distributions merely reinforces the similarity of the two samples.

Suggestions for Future Research

Attention Deficit Behavior

As the behavior variable was the most efficient discriminating factor separating the VLBW from the FBW group, further research employing instruments more sensitive to the varying aspects of attention deficit behavior is recommended. It may be that certain dimensions of this behavior are more efficient in discriminating the groups. This information would provide for more precise characterization of the VLBW group and, hopefully, more successful intervention if these behavior patterns prove to be troublesome.

Socio-economic Status

Socio-economic status also appears to have a powerful influence upon various factors relating to the condition of VLBW as well as educational, cognitive, and behavioral outcome of the subjects. Further research examining this very complex factor in greater depth is recommended. The interaction of initial deficit, genetic potential, environmental effects, and future intellectual and academic performance are recognized as extremely important, although the relationship is not entirely clear. Single indices of SES tend to be too general to provide adequate information for clarification of this dynamic factor. Investigation of specific elements related to SES may be more useful. Marital status, stress in the home, cultural background, family size, and maternal health may influence outcome in different ways. Research by Robertson and Finer (1988) suggested that educational levels of both mother and father as well as IQ levels of the parents may be more important than occupational status in determining outcome. An investigation of the interaction of SES with varying practices in child rearing in the VLBW population would also provide valuable information. The association of maternal age with SES warrants investigation as well.

Learning Disabilities Research

As assessments in the preschool years have limited generalizability in learning disabilities research, two suggestions for further investigation are made. First, the predictive validity of various measures used in preschool screening for learning disabilities must be established. Second, follow-up studies of VLBW subjects must be extended well into the elementary school years and beyond to clarify the ways in which the complex factors associated with VLBW interact with the sophisticated demands of schooling at higher levels.

Neurological Status

Research suggests that, although increasing proportions of VLBW infants are not impaired, a high risk category exists when very low birthweight is associated with indicators of neurological pathology (Calame, Fawer, Claeys, Arrazola, Ducret & Jaunin, 1986; Drillien, 1972; Fitzhardinge & Ramsay, 1973; Pape, Bunic, Ashby, & Fitzhardinge, 1978). Studying the nature and degree of neurological dysfunction associated with future learning disabilities of various types in the VLBW population would not only lead to greater accuracy in predicting outcome, but would also expand the field of knowledge in the general area of learning disabilities.

Conclusions

The results of this study, although viewed with caution, must be considered to be very encouraging to researchers in the fields of neonatalogy and educational psychology. The group of nondisabled survivors of VLBW, although comprising only 30% of the original group of admissions to the neonatal intensive care units, appears to be a healthy group, not only physically, but cognitively as well. Medical practitioners and support professionals can, with some certainty, counsel families of VLBW infants to expect those known to be free of major disabilities in infancy, and appropriate for gestational age, to approach the school years without anticipating major problems. Early signs of attention deficit behavior must be heeded and appropriate guidance provided. Ideally support must also be given to families from lower socio-economic levels and to very young mothers. The major conclusion of this study must be, however, that early intervention and intensive care treatment is realizing results. Improvements in survival rates are accompanied by improvements in the quality of life for those who survive.

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Appendix A

Method for Reporting Test Results

Variable	Score Derivation	
Stanford Binet	IQ	$\bar{X} = 100$
PPVT	Standard Score	$X = 100$
VMI	Age Score Difference	
	(Mental Age - Chronological Age + 100)	
David's Behavior Scale	Raw Score	range 6-36
	Category	Normal < 19
		Suspicious 19-23
		Hyperactive >23
Wepman Auditory Discrimination	Category	1-5
		1 indicates weakest ability
Rhyming	Raw Score	range 0-13
Sound Blending	Stanine	range 1-9
School Language and Listening	Raw Score	range 0-15
Letter Recognition	Raw Score	range 0-11
Visual Matching	Raw Score	range 0-14
	(Mental Age - Chronological age + 100)	
Pictorial Absurdities	Age Score Difference	
Quantitative Language	Raw Score	range 0-11
Auditory Attention Span	Age Score Difference	
	(Mental Age - Chronological age + 100)	
Draw-a-man	IQ	$\bar{X} = 100$
Auditory Memory	Raw Score	range 0-12

APPENDIX B

Test Results of Subjects with Lowest Birthweight and Earliest Gestational Age

Variable	Subject with Lowest Birthweight	Subject with Earliest Gestational Age
Gender	Male	Female
Birthweight	851 grams	900 grams
Birthweight Percentile	45	60
Gestational Age (weeks)	26 weeks	25 weeks
Chronological Age (years & months)	5-4	5-6
Socio-economic Index	6	6
Mother's Age	18	27
Stanford Binet IQ	102	102
PPVT Percentile	91	89
PPVT Standard Score	118	115
VMI Age	4-1 (15 month delay)	4-5 (12 month delay)
David's Behavior	18 (normal)	20 (suspicious)
Wepman Auditory Discrimination	4-above average	3-average
Metropolitan Readiness Percentile	28	24
Metropolitan Readiness Subtests:		
Rhyming-Raw Score & Category	3-low	5-low
School Language and Listening	10-average	11-average
Letter Recognition	10-average	11-average
Visual Matching	9-average	7-low
Quantitative Language	7-average	9-average
Auditory Memory	8-average	10-average
Gate's MacGinitie Sound Blending Stanine	7	3
Detroit Subtests:		
Pictorial Absurdities Age	6-0 (8 month advance)	4-6 (12 month delay)
Auditory Attention Span for Related Syllables Age	7-0 (20 month advance)	4-6 (12 month delay)

APPENDIX C

Group Variable Means for Categories of Mothers Age

Variables	Age in Years				
	15-20	21-25	26-30	31-35	>35
Stanford Binet	96.8	110.0	107.2	107.7	99.0
PPVT	100.5	106.6	104.8	98.6	91.8
VMI	89.7	98.5	94.5	96.1	93.6
David's Beahvior Scale	20.9	20.1	20.0	20.6	22.4
Wepman Auditory Discrimination	2.6	3.5	3.3	3.4	2.8
Rhyming	5.8	8.9	7.3	7.4	7.8
Sound Blending	4.4	5.6	5.0	5.0	5.2
School Language & Listening	9.6	10.5	10.1	10.6	9.0
Letter Recognition	7.4	9.8	9.2	9.3	10.4
Visual Matching	8.1	9.5	9.1	9.4	9.6
Pictorial Absurdities	92.1	95.1	93.3	93.4	94.8
Quantitative Language	6.7	7.7	7.4	6.9	6.6
Auditory Attention Span	88.0	103.9	92.5	114.7	85.6
Draw-a-Man	86.2	91.2	88.8	94.6	96.2
Auditory Memory	7.4	8.8	8.0	8.4	9.2

APPENDIX D

Group Variable Means for Categories of SES

VLBW Sample

Variables	Blishen Category *				
	1 & 2	3	4	5	6
Stanford Binet	120.5	110.6	108.9	103.5	100.2
PPVT	108.5	109.2	103.0	102.2	100.3
VMI	104.0	94.4	94.7	97.8	91.6
David's Beahvior Scale	17.3	21.1	19.6	20.1	21.1
Wepman Auditory Discrimination	3.5	3.4	3.1	3.5	2.9
Rhyming	11.8	8.0	8.1	7.5	6.3
Sound Blending	6.5	5.3	5.4	4.5	4.8
School Language & Listening	11.8	10.6	10.3	10.5	9.4
Letter Recognition	11.0	9.7	8.8	9.3	8.4
Visual Matching	13.0	9.6	9.2	8.8	8.4
Pictorial Absurdities	106.8	95.0	96.2	92.2	90.8
Quantitative Language	9.2	7.6	7.7	7.7	6.3
Auditory Attention Span	93.0	98.1	101.1	100.5	92.1
Draw-a-Man	98.0	91.0	95.3	86.0	87.6
Auditory Memory	10.3	8.1	9.4	7.6	7.6

* Category 1 indicates highest SES

APPENDIX E

Group Variable Means for Categories of SES

FBW Sample

Variables	Blishen Category *				
	1 & 2	3	4	5	6
Stanford Binet	110.8	114.8	109.5	106.8	102.6
PPVT	109.9	115.6	111.9	108.1	95.7
VMI	99.2	98.5	96.1	97.4	96.1
David's Behavior Scale	14.3	14.8	14.9	16.4	15.8
Wepman Auditory Discrimination	4.3	3.6	3.8	3.7	3.4
Rhyming	8.8	11.2	8.1	8.7	7.8
Sound Blending	6.0	7.0	6.0	5.8	4.8
School Language & Listening	10.4	11.5	10.8	10.4	10.1
Letter Recognition	10.3	10.6	9.6	8.9	9.4
Visual Matching	10.6	10.5	9.5	9.6	9.4
Pictorial Absurdities	97.4	94.0	98.0	96.8	96.3
Quantitative Language	7.9	8.5	8.1	7.5	7.2
Auditory Attention Span	94.7	112.1	99.4	95.0	89.8
Draw-a-Man	98.5	93.8	97.4	98.0	94.3
Auditory Memory	8.8	10.4	8.7	8.4	8.4

* Category 1 indicates highest SES

APPENDIX F

Group Variable Means for Categories of IQ

VLBW Sample

Variables	IQ Groups				
	70-85	86-100	101-115	116-130	131-145
PPVT	79.6	98.1	105.0	112.2	111.0
VMI	85.4	90.9	95.4	99.8	100.0
David's Behavior Scale	23.3	20.9	20.2	19.4	18.5
Wepman Auditory Discrimination	1.4	2.9	3.5	3.6	3.5
Rhyming	3.0	6.8	7.2	9.6	12.0
Sound Blending	3.7	4.5	4.9	6.2	5.0
School Language & Listening	5.3	9.7	10.6	11.0	13.5
Letter Recognition	4.7	8.2	9.3	10.7	10.5
Visual Matching	5.3	8.0	9.3	10.6	13.5
Pictorial Absurdities	79.9	92.8	93.7	98.4	101.5
Quantitative Language	3.4	6.7	7.7	8.2	9.0
Auditory Attention Span	70.6	87.9	99.7	111.0	105.0
Draw-a-Man	81.0	86.1	89.9	96.1	105.5
Auditory Memory	3.9	7.6	8.7	9.1	11.5

APPENDIX G

Group Variable Means for Categories of IQ

FBW Sample

Variables	IQ Groups 70-85	 86-100	 101-115	 116-130	 131-145
PPVT	88.4	96.2	109.7	116.8	119.9
VMI	84.7	96.1	97.1	99.1	104.0
David's Behavior Scale	19.3	17.3	15.8	12.9	12.7
Wepman Auditory Discrimination	3.3	3.4	3.8	3.9	4.5
Rhyming	5.3	6.2	9.4	10.0	11.9
Sound Blending	4.6	4.9	5.9	6.2	7.9
School Language & Listening	7.6	9.6	10.6	11.6	12.2
Letter Recognition	6.1	8.8	10.1	9.8	10.9
Visual Matching	7.4	8.5	9.9	11.0	11.9
Pictorial Absurdities	89.3	93.8	96.7	101.3	101.7
Quantitative Language	5.9	6.6	8.0	8.5	9.4
Auditory Attention Span	75.6	85.0	94.1	110.3	122.9
Draw-a-Man	79.6	95.0	97.3	98.9	105.4
Auditory Memory	4.9	8.2	8.8	9.4	10.5

APPENDIX H

Group Variable Means for Behavior Categories

VLBW Sample

Variables	Behavior Categories		
	Hyperactive	Suspicious	Normal
Stanford Binet	95.6	106.0	108.3
PPVT	96.1	103.7	104.9
VMI	89.9	96.4	9.38
Wepman Auditory Discrimination	2.5	3.2	3.4
Rhyming	5.9	7.3	8.3
Sound Blending	4.6	4.7	5.7
School Language & Listening	8.8	10.3	10.4
Letter Recognition	7.9	9.2	9.1
Visual Matching	7.6	9.1	9.7
Pictorial Absurdities	88.3	94.2	97.4
Quantitative Language	5.6	7.3	8.0
Auditory Attention Span	96.7	98.4	94.4
Draw-a-Man	86.5	90.5	90.6
Auditory Memory	7.6	8.0	8.6

APPENDIX I

Group Variable Means for Behavior Categories

FBW Sample

Variables	Behavior Categories		
	Hyperactive	Suspicious	Normal
Stanford Binet	93.8	103.3	109.9
PPVT	100.6	106.0	107.8
VMI	90.5	95.7	98.0
Wepman Auditory Discrimination	3.2	3.8	3.7
Rhyming	6.6	8.1	8.9
Sound Blending	4.9	5.6	5.8
School Language & Listening	8.5	10.4	10.7
Letter Recognition	7.2	9.7	9.7
Visual Matching	6.2	9.5	10.1
Pictorial Absurdities	94.5	95.2	97.4
Quantitative Language	6.8	7.6	7.8
Auditory Attention Span	87.3	90.4	98.2
Draw-a-Man	85.8	95.2	98.0
Auditory Memory	6.7	8.3	9.0

APPENDIX J

Child's Name ______________________________ Birth Date __________

Rater's Name ______________________________ Date of Rating __________

Please rate the child on each of the characteristics (or behavior) listed on the following scales. Place a check mark at the point on the scale indicative of your estimate of the degree to which the child possesses the particular characteristic.

As you make each rating, judge the child in comparison with other children of the same sex and age. That is, the ratings should indicate your estimate of the child's behavior in comparison with the behavior displayed by other "normal children."

For each of the characteristics, which are defined below, place a check mark at one of the six points on the scales running from "much less than most children" to "much more than most children." Do not mark the midpoint on any of the scales. Even though it may sometimes be difficult to make a judgment, please make a rating on one or the other side of the scale.

1. Hyperactivity - Involuntary and constant overactivity; advanced motor development (throwing things, walking, running, etc.; always on the move; rather run than walk; rarely sits still.

Much Less Than Most Children	Less	Slightly Less	Slightly More	More	Much More Than Most Children

2. Short Attention Span and Poor Powers of Concentration - Concentration on a single activity is usually short, with frequent shifting from one activity to another; rarely sticks to a single task very long.

Much Less Than Most Children	Less	Slightly Less	Slightly More	More	Much More Than Most Children

3. Variability - Behavior is unpredictable, with wide fluctuations in performance; "sometimes he (or she) is good and sometimes bad."

Much Less Than Most Children	Less	Slightly Less	Slightly More	More	Much More Than Most Children

4. Impulsiveness and Inability to Delay Gratification - Does things on the spur of the moment without thinking; seems unable to tolerate any delay in gratification of his (her) needs and demands; when wants anything, he (she) wants it immediately; does not look ahead or work toward future goals; thinks only of immediate present situation.

Much Less Than Most Children	Less	Slightly Less	Slightly More	More	Much More Than Most Children

5. Irritability - Frustration tolerance is low; frequently in an ugly mood, often unprovoked; easily upset if everything does not work out just the way he (she) desires.

Much Less Than Most Children	Less	Slightly Less	Slightly More	More	Much More Than Most Children

6. Explosiveness - Fits of anger are easily provoked; reactions are often almost volcanic in their intensity; shows explosive, temper-tantrum type of emotional outbursts.

Much Less Than Most Children	Less	Slightly Less	Slightly More	More	Much More Than Most Children